RESEARCH REPORT
1960

COFFEE RESEARCH STATION
LYAMUNGU
TANGANYIKA

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LYAMUNGU,
TANGANYIKA.

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CONTENTS

	Page
PREFACE	5
STAFF OF THE COFFEE RESEARCH STATION	6
INTRODUCTION	7
PUBLICATIONS	11
THE SELECTION OF ARABICA COFFEE AT LYAMUNGU. I. THE 'N' SERIES	12
A COMPARISON OF THE MULTIPLE AND SINGLE STEM PRUNING SYSTEMS UNDER CONDITIONS OF LIGHT SHADES	18
THE ACTION AND VALUE OF VEGETABLE MULCHES ON THE NUTRITION OF ARABICA COFFEE TREES IN THE NORTHERN PROVINCE OF TANGANYIKA	25
EXPERIMENTS AND OBSERVATIONS ON THE CONTRIBUTION OF A DRY TOPSOIL TO MINERAL DEFICIENCIES IN THE ARABICA COFFEE TREE	34
COFFEE LEAF MINER EPIDEMICS IN RELATION TO THE USE OF PERSISTENT INSECTICIDES	43
THE EFFECT OF CAPTAN AND COPPER SPRAYS ON LEAF RUST AND LEAF FALL OF ARABICA COFFEE	56
SURVEY OF RACES OF ARABICA COFFEE LEAF RUST IN NORTHERN TANGANYIKA	60
THE COMMERCIAL CROP AT THE COFFEE RESEARCH STATION ...	62
A REVIEW OF COFFEE SEED ISSUES FROM THE COFFEE RESEARCH STATION IN RECENT YEARS	65

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PREFACE

The Coffee Research Station, Lyamungu was formally opened in 1934; between 1934 and 1957 a regular Annual Report was produced in which the results of all research undertaken on the station, were published. No report has been published however, since 1956/57.

After a careful review of the present position and bearing in mind our primary duty which is (a) to provide the solution to problems the control of which will lead to increased economic production of quality coffee and (b) to find and/or investigate new techniques and methods of economic coffee production, it has been decided to alter the format of the annual report.

The Annual Research Report, of which this is the first one, does not set out to report all the research and investigation work being undertaken on the Coffee Research Station. Instead, studies of interest and investigations which have reached a stage where conclusion can be drawn and tentative or definite recommendations can be made to the industry, will be reported simply and concisely in an easily readable form; tables, diagrams and illustrations will be simple, as concise as possible, and to the point.

In addition to this Report, technical papers describing the results of specific research projects will be submitted for publication in the international journals of the Agricultural Sciences from time to time; articles of an advisory nature and the results of ad hoc, short term investigations together with advisory notes, will appear in the monthly publication entitled Tanganyika Coffee News. Extension and advisory information is disseminated through the Extension (Field) Services, Agricultural Department, Ministry of Agriculture and Co-operative Development, in the form of reports and articles and by joint advisory tours in the coffee growing areas with the staff of this Station.

STAFF, DECEMBER 1960

Director :
J. B. D. ROBINSON, B.Sc. (HONS.) Agric. Chem. (READING), F.R.I.C.
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Northern Regional Research Centre, Tengeru, (Visiting)

Plant Physiologist :
VACANT

Chemist :
VACANT

Agronomist :
VACANT

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Assistants to Entomologist :
M. E. A. MATERU, B.Sc. (MAK.)
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Senior Field Assistant :
S. B. MANGALE (Assistant Farm Manager, Lyamungu)

INTRODUCTION

The distribution of rainfall on the Coffee Research Station during 1960 was most unsuitable for the coffee. In April rainfall was excessive and in mid May it virtually ceased. Three dry months in August, September and October and the absence of any effective Short Rains in November and December, resulted in considerable leaf fall during the first period whilst the crop was being harvested and little recovery in terms of leaf production, during the latter two months of the year, until after irrigation water had been applied during December.

A summary of the rainfall for a period of 25 years is given in Table I together with air temperature (screened) and relative humidity values.

TABLE I

Summary of some Climatic data for the Coffee Research Station

Month	Monthly Rainfall (inches) (1935—1959)		1960	Air Temperature (°C) (1936—1959)		Relative Humidity (%) (1938—1959)	
	Mean	Range		Mean Max.	Mean Min.	9 a.m.	3 p.m.
January	1.71	0.11(1935)— 7.22(1956)	5.06	28.4	14.2	90	57
February	2.51	0.13(1937)— 8.91(1935)	0.10	29.0	14.2	90	56
March	4.30	0.10(1949)— 15.02(1942)	4.76	27.9	14.9	82	63
April	19.43	7.95(1943)— 37.23(1937)	33.34	25.0	16.0	97	76
May	18.29	4.76(1959)— 33.05(1937)	12.42	22.5	15.4	97	83
June	4.44	0.92(1949)— 10.97(1947)	4.63	21.1	14.0	96	76
July	2.06	0.30(1954)— 5.22(1959)	1.13	20.6	12.9	96	72
August	1.29	0.13(1958)— 2.58(1940)	0.19	21.6	13.0	95	67
September	1.26	0.05(1959)— 7.34(1946)	0.01	23.8	12.8	94	59
October	1.15	0.01(1958)— 4.71(1946)	1.53	25.9	13.0	90	57
November	2.72	0.30(1958)— 9.23(1957)	1.11	27.0	14.0	90	62
December	2.59	0.30(1945)— 9.72(1941)	0.25	27.3	14.5	91	62
Mean Annual Rainfall	61.64	32.30(1949)—100.68(1937)	64.53	Absolute Max. 33.6 (16.3.46 / 21.3.46)	Absolute Min. 7.4 (10.8.59)		

The histograms in Figure 1 shows more clearly the mean monthly rainfall distribution throughout the year and particularly the very high mean annual precipitation in the months of April and May; Figure II illustrates the variation in annual precipitation during a twenty-six year period.

The staff position is not at all satisfactory at the present time; the posts of Plant Physiologist and Plant Pathologist remain vacant, although we have the part time services of Mr. D. A. Burdekin Plant Pathologist, Northern Regional Research Centre, Tengeru, who is carrying out as much coffee pathology work as he can manage. The post of Agronomist has been vacant since Mr. A. J. M. Gunn left to go on leave in May 1960 pending transfer elsewhere in Tanganyika. Finally, Mr. J. C. Warden, Chemist, resigned in October this year whilst on leave. It is now becoming extremely difficult for the remaining members of the Specialist Staff to maintain the research programme on the Station and it seems probable that some at least will have to be held in abeyance.

Some sections of the 'Handbook on Arabica Coffee in Tanganyika' which was published during 1959 by the Tanganyika Coffee Board, still remain to be completed but it is difficult to see how this will be accomplished in the immediate future.

In this Report the Horticulturist has written the first of a series of papers dealing with the coffee selection work that has been carried out in Tanganyika and

FIGURE I

MEAN MONTHLY RAINFALL.

25 YEAR MEANS. 1935 - 1959.

COFFEE RESEARCH STATION. LYAMUNGU. TANGANYIKA.

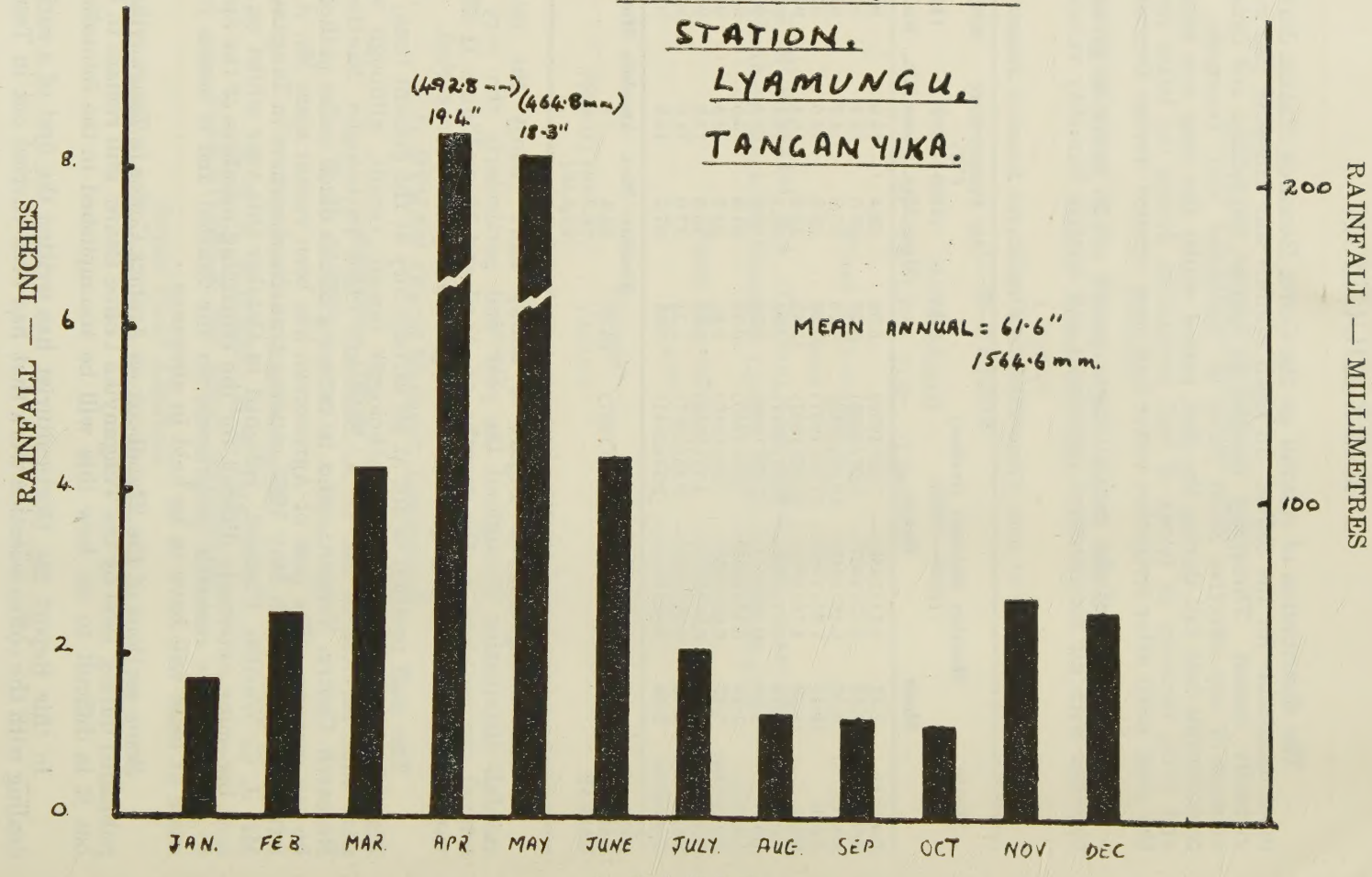
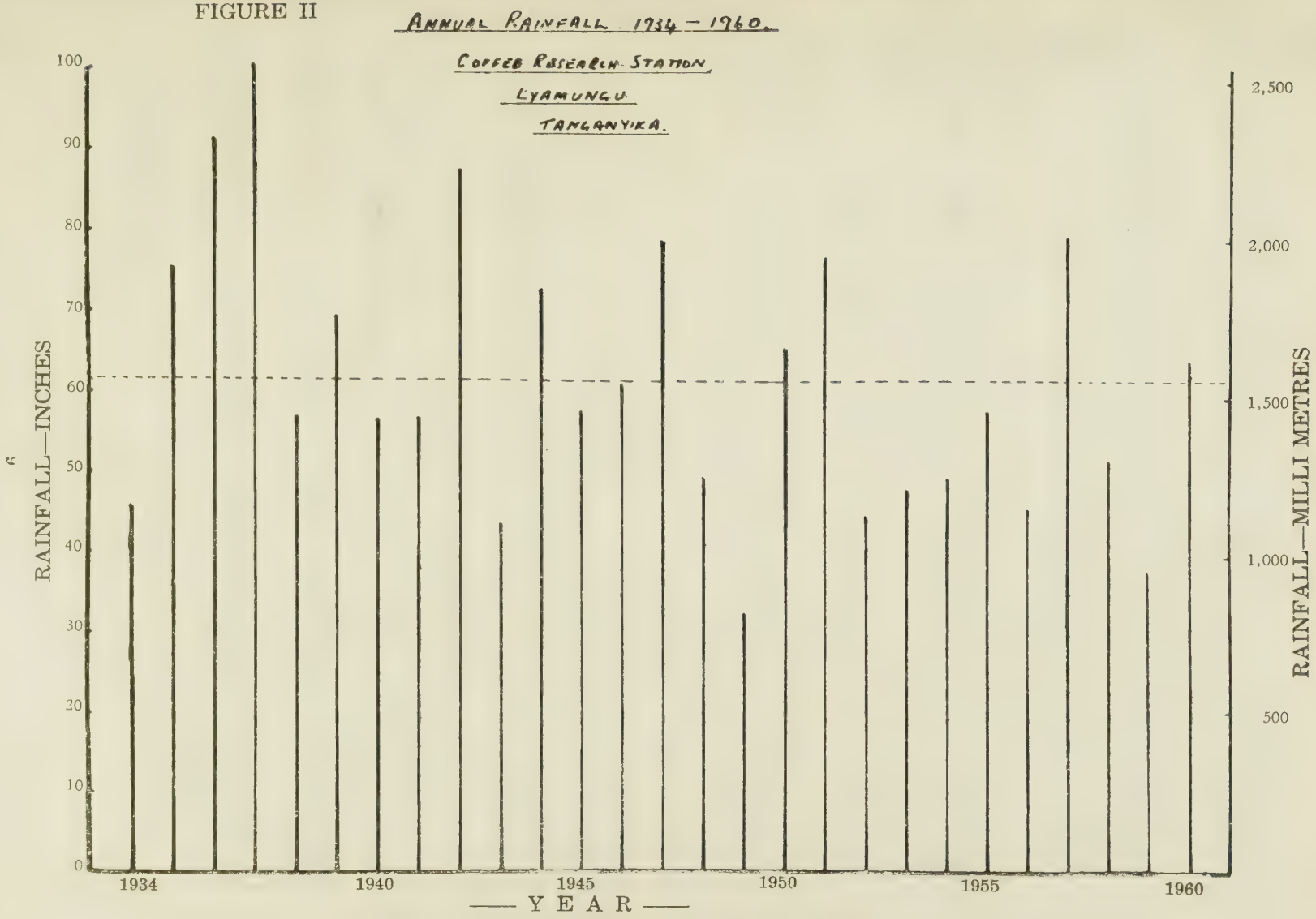


FIGURE II


ANNUAL RAINFALL 1934 – 1960.
COFFEE RESEARCH STATION
LYAMUNGU
TANGANYIKA.
RAINFALL—INCHES
RAINFALL—MILLI METRES
100
90
80
70
60
50
40
30
20
10
0
2,500
2,000
1,500
1,000
500
1934
1940
1945
1950
1955
1960
— YEAR —

which has resulted in the present improved seed selections which are issued to coffee growers throughout the territory. He has also summarized the results obtained from a long term trial comparing the multiple versus the single stem pruning systems carried out on this Station.

The Chemist has summarized the past work which has been carried out to evaluate mulching in coffee with different materials under the climatic conditions of this Station and has presented some preliminary data to show the influence of dry soil conditions upon the mineral composition of the coffee tree as evidenced by leaf analysis data. The effectiveness of mulch application in coffee will increase as rainfall decreases when the distribution is such that drought periods occur between well defined rainfall seasons.

The Entomologist has been concerned with the effects that the application of persistent insecticides used in coffee for controlling such pests as antestia (*Antestiopsis lineaticollis*) may have on outbreaks of leaf miners (*Leucoptera meyricki* Ghes. and *Leucoptera caffeina*. Wash.). He has shown that under certain conditions the application of D.D.T. or Dieldrin can both prolong and intensify leaf miner attack.

The visiting Plant Pathologist reports on some comparative tests with copper and captan fungicides applied to coffee to control leaf rust (*Hemilei vastatrix* Berk. and Br.) and as anti-leaf-fall sprays. A survey of leaf rust races present in Tanganyika is being undertaken on both arabica and robusta coffees to determine which races are present and their distribution. This knowledge is essential both for assessing the potential value of new resistant/immune coffee varieties (arabica) as well as forming a basis for our controlled programme of breeding for leaf rust immunity. This work, which has a high priority on our research programme is making satisfactory progress at the present time and some interesting results have already been achieved.

During the year a number of Advisory visits have made by Specialist Staff members to different plantation coffee areas and areas of peasant production. These include plantations in the Arusha, Moshi, Oldeani, Mbeya, Mbozi, Rift Wall and Usumbara areas and peasant production areas on Kilimanjaro and Meru, and at Mto-wa-mbu, Mbulumbulu, West Lake Province, N. Mara (E. Lake Province), Mbozi, Tukuyu, (Rungwe area) Southern Highlands Province, and Songea (Matengo area) Southern Province. Advisory Reports have been written following these visits.

The experimental programmes on the Coffee Sub-Stations at Maruku including Kituntu and Kaibanja (W. Lake Province, robusta and arabica coffee), Mbimba and Mitalula (Southern Highlands Province, arabica coffee) have been reviewed and a programme for the future work has been drawn up for each one.

Finally, this Report also contains a brief summary of yields and quality of the commercial coffee produced on the Coffee Research Station over the past 14 years together with a survey of the coffee seed issued from here over the past 14 years.

In the 1959/60 crop season, a total of 61.32 tons of clean coffee was produced; of this 48.3% was in the first three quality classifications and 50.7% was graded 'A' or 'AA', with 6.9% 'PB' and 10.7% 'B' grades. The average yield was 8.18 cwts. of clean coffee per acre.

J. B. D. ROBINSON,
SENIOR RESEARCH OFFICER

PUBLICATIONS

The following articles were published in the *Tanganyika Coffee News* during 1960: —

July. "Yellow Coffee Trees and Fertilizer Use," by J. C. Warden.

August. "Coffee Seed—1960/61 Season," by L. M. Fernie.

September. "Spray Programme for Arabica Coffee—1960/61 season," by R. G. Tapley.

October. "A Summary of the Recommended Methods of Controlling Major Coffee Pests," by R. G. Tapley.

"Some Simple Rules for the Pruning of Coffee," by L. M. Fernie.

December. "Root Diseases of Coffee," by D. A. Burdekin.

"Notes on a brief visit to the Mbozi area," by J. B. D. Robinson.

"Coffee Production and Protection," by J. B. D. Robinson.

Articles published in the other Journals during 1960: —

Tapley, R. G. and Znatowicz S. W. E., The Incidence of Parathion Poisoning in Spray Operators. *Kenya Coffee,* 1960, 25, 217.

Burdekin, D. A., Wind and Water Dispersal of Coffee Leaf Rust in Tanganyika. *Kenya Coffee,* 1960, 25, 212.

Tapley, R. G. The White Coffee Borer *Anthores leuconotus* Pasc. and its Control, Buli. Ent. Res., 1960, 51, 279.

THE SELECTION OF ARABICA COFFEE AT LYAMUNGU:

I. The "N" Series

By L. M. FERNIE, HORTICULTURIST

INTRODUCTION

The 'N' series of the Lyamungu selections originated at the Roman Catholic Mission at Kilema on the South-eastern slopes of Mt. Kilimanjaro, at an altitude of approximately 4,300 feet above sea level. The seed from which the plants were raised was supposedly obtained from the Roman Catholic Mission at Morogoro, where the original plantings of **arabica** coffee were made in 1883/84. Seed for the Morogoro plantings was introduced from the island of Réunion (Bourbon), and so the Kilema trees would appear to be second generation plants of the Bourbon variety.

During the 10 years 1950-59 inclusive, some 23,230 lb. of seed of the 'N' series, representing 14 'N' selections, have been distributed from Lyamungu to growers in Tanganyika. This amount represents 49.7% of all the seed distributed during this period.

The outstanding feature of the 'N' series has been the consistently high quality maintained by a number of the selections and their progeny, particularly N 5, N 30, and N 39.

In addition, mention must be made of the yields of N 197 which has proved to be the highest yielding selection within the so-called Bourbon variety over a wide range of conditions. In the more recent trials at Lyamungu, N 39 is also proving a good yielder, especially on multiple stem without shade.

THE KILEMA PLOT

Seed from the Morogoro trees was brought to Kilema and planted in 1893. Thus the trees were assumed to be about 40 years old when their yields were first recorded in 1934. Certainly, during their life, many of them had been stumped back at least once and some in-filling had taken place; the pruning system was indeterminate and probably unsystematic, although all trees had been capped into some semblance of the single stem system at one time. The plot was protected from the prevailing wind, but was not directly shaded, except for an occasional interplanted fruit tree (banana and peach). The spacing was variable and irregular.

Both bronze and green-tipped trees were found. According to Haarer (3) both young and old leaves of the Bourbon variety are pale-green in colour, and if this is accepted as a varietal characteristic (although both bronze and green-tipped trees are found in some other varieties), then there must either have been some unrecorded in-filling with another variety subsequent to the original planting, or else the original seed was mixed. A possible clue may be found

PLATE 1 *(Photo: S. Znatowicz.)*

The Kilema plot: a general view of the coffee as it appears in 1960.

PLATE 2 *(Photo: S. Znatowicz.)*

The Kilema plot: a contrast in cultural methods. The ground on the right is kept swept clean, while heavy mulching with local debris is shown on the left.

in a further statement of Haarer's (3) that a strain from Java known as 'Menado' was apparently imported prior to 1914 and planted extensively in the Usambara Mountains and also at Mission stations in the Iringa district. This strain was said to have the characteristics of Bourbon but with bronze colouring of the young leaves, and Haarer goes on to say that "similar coffee is now (1930) intermingled with Bourbon on many of the Kilimanjaro and Arusha plantations".

It should be noted that the majority of the selections subsequently isolated from the 'N' series were bronze-tipped, and visiting experts from Central and South America have more recently confirmed that these trees do not resemble the Bourbon variety as known in Latin America. Some of the earlier selections, later discarded (e.g. N. 50, N.100), appear to be a more typical Bourbon type as regards leaf shape and colour. It is interesting to note that the 'R' series, located at Machame Lutheran Mission and reputed to be about 10 years younger than the 'N' series, are supposedly the F1 progeny of the 'N' series from Kilema and all exhibit the typical Bourbon leaf characteristics. Selections of the 'R' series, which were promising at one time, have now been discarded entirely. Until a more definite identification has been made, all selections of the 'N' series will continue to be known as Bourbon.

From material submitted to the Coffee Rust Research Centre in Portugal it has been established that the 'N' series displays the typical Bourbon reaction to leaf rust (*Hemileia vastatrix*), and is susceptible to the important rust races endemic in East Africa, viz. I and II.

SELECTION

Arrangements were made in 1934 for the recording of the individual yields of 241 trees in the Kilema plot, and after five years the average yield was the highest of the plots then being investigated in different localities throughout the Territory (1). From the total number, 60 provisional selections were made, of which 9 were stumped back for propagation purposes after the first year. Seven years records were completed before the war necessitated the cessation of this work.

A study of the yield results of the 51 selections showed a very definite irregular bearing habit, often biennial but not rhythmically so, with a tendency for some trees to become seasonally out-of-step. It was a coincidence that the first year (1934) proved to be one of very high yields throughout the plot. Of the 51 selections, six yielded an average of over 15 cwt/acre of clean coffee for seven years and a further 23 exceeded 12½ cwt/acre.

In 1939 (2), there were eleven trees of the 'N' series included amongst the 16 best potential selections, which were chosen mainly for yield and quality and were grouped into four classes; of the three trees in the first class group, two were N. 39 and N. 197 respectively, each with a liquoring quality rated as good-to-fine.

CLONAL TRIALS AT LYAMUNGU

Twenty-six of the 60 potential selections mentioned above were successfully propagated by cuttings and were planted out on the Coffee Research Station, with clonal selections from other localities, in a series of 6 x 6 Latin squares comprising Experiment XVIII, as the requisite number of plants were rooted. Annual and average yield results from these trials are now available for periods of years ranging from 8 to 16, and from these results have been derived the final selections of the 'N' series, seed of which is sold to growers at the present time. Examples of some of the yields obtained are shown in Table II.

TABLE II

Some examples of the yields, expressed as cwt./acre clean coffee, of the final selections of the 'N' series and their progeny.

Selection	Mother-tree		Clone				Seedling			
			C.R.S. Trials		External Trials		F1 C.R.S. Trials		F2 C.R.S. Trials	
	Mean Yield	*No. of Years*	*Mean Yield*	*No. of Years*	*Mean Yield*	*No. of Years*	*Mean Yield*	*No. of Years*	*Mean Yield*	*No. of Years*
N. 5	14.55	7	10.54	12	6.26	5	6.66	17	—	—
N. 39	16.83	7	14.53	6	15.87	5	8.05	17	17.10	4
N. 69	13.75	7	—	—	—	—	8.08	17	—	—
N. 197	13.88	7	12.22	13	18.90	5	6.60	17	—	—
N. 205	14.07	7	11.97	13	7.82	5	—	—	—	—
N. 218	15.04	7	10.80	14	17.48	5	—	—	—	—

Yield has not, however, been the only criterion, and liquoring quality especially among other characteristics has been taken into consideration.

Samples from all selections in Expt. XVIII were submitted to a Liquorer for quality reports for six or more successive years from 1948 onwards. The results were outstandingly good in respect of some of the 'N' series and examples of the classes attained are shown in Table III.

TABLE III

Examples of the quality classes attained by 'A'—grade samples from trials at Lyamungu

	N. 5		N. 30	N. 39		N. 197		N. 205	N. 218
	Clone	*Seedling*	*Clone*	*Clone*	*Seedling*	*Clone*	*Seedling*	*Clone*	*Clone*
1948	1	1	1	1	1+	1	1	1	2
1949	3	3	1	1	1	2—	2	2—	1
1950	1	3	1	1	1	2—	2	2—	—
1951	2	2	2	3+	1	2	1	1—	1
1952	1—	—	1—	2	—	1—	—	1—	1
1953	1	—	1	1	—	3	—	1	2
1954	—	—	1	2	—	2—	—	2	1
1955	—	—	3+	2	—	—	—	3	2

SEEDLING PROGENY TRIALS AT LYAMUNGU

(a) F1 GENERATION

These were located in Experiment II, an area comprising four 6 x 6 Latin squares with 25-tree plots and two randomized blocks each with 9 selections in 16-tree plots. Thirteen of the 'N' series were represented and N.39 occurred twice.

Yield results, which cover 17 years, were generally poor throughout the area; those of the final selections, where available, are shown in Table II. They were

never intended to be comparable with those of the respective clones, and are quoted as a matter of interest.

In 1948-50 and 1953-56 individual tree recording of the most promising selections in this area was carried on. The F1 progeny of four of the 'N' series, namely N.39, N.69, N.182, and N.197, were included in this project, which resulted in 2 trees of N.39, 21 trees of N.69, 3 trees of N. 182, and 8 trees of N. 197 being located, each having an average yield of over 15 cwt./acre.

This number was finally reduced to four selections the yield details of which are shown in Table IV.

TABLE IV

Yields of individual tree selections of the F1 generation, expressed as cwt./acre clean coffee.

Selection	1953	1954	1955	1956	Mean
N.69/79	30.34	8.70	37.76	12.62	22.36
N.69/84	22.91	11.24	37.12	12.30	20.89
N.69/87	31.29	16.71	29.06	7.53	21.15
N.197/90	15.49	22.27	21.74	17.93	19.36

The consistency of N.197/90, the yields of which never fell below 15 cwt./acre in each of the four years, should be noted.

The classes attained from quality tests carried out over four successive years from 1948-1951 are shown with those of the clones in Table III. The outstanding results achieved by N.39 in this respect, with a class 1 each year in both of the Latin squares in which it is represented, is additional proof of the inherent fine quality of this selection.

(b) F2 GENERATION

The progeny of two of the F1 generation of N.39 have been planted out as the F2 generation in further trials. They are N.39/117 and N.39/144. Early results in an experiment where yields have been high (XXII) show that the yields of both these selections compare favourably with those of the Kent selections.

EXTERNAL TRIALS

The maintenance of external trials has proved to be difficult, and results available are lamentably few. All seedling selection trials planted or projected before the war had to be abandoned, while the majority of the post-war plantings (clonal) suffered for a number of reasons generally associated with change of ownership and management difficulties. Nevertheless, it is possible to make some observations on the behaviour of the 'N' series under different conditions.

YIELDS

It must be noted that yields from external trials are usually lower than those achieved at Lyamungu. This is ascribed to environment and management. An exception is provided by the low-altitude trial at Mbosho (3700') on S. Kilimanjaro, where vigorous growth and very high yields were recorded in the early years of the trial. At the other extreme, yields at an altitude of approximately 5,500' on the south-eastern slopes of Kilimanjaro have been very low, averaging only 3¾ cwt./acre clean coffee over 7 years.

Both N.197 and N. 218 were represented in each of these places, and both proved to be amongst the best in each case. N.197 has also proved to be good in two trials in the Arusha area, and in view of the number of trials in which

this selection has been successfully planted, it must be considered to have proved its worth as the most consistent high-yielding selection of the Bourbon variety under a wide range of conditions.

N.205 has not been widely planted but it has been very successful both at Arusha and at Lyamungu, especially on single stem.

The yields of N.39 were rather disappointing in the low altitude trial but they were comparatively good in other areas; this selection was not represented in the trial at the high altitude.

Examples of the better yields obtained are shown in Table II.

QUALITY

The difficulty of processing samples in a fresh condition when they have to be transported for a considerable distance militates against the production of good quality coffee. The investigation of quality over a period of years has also been greatly hampered by the difficulties of management and control mentioned earlier. Nevertheless, some results for the 'N' series are available.

The consistently high quality of N.39 over a range of conditions in the Kilimanjaro and Meru areas is confirmed. Some good reports were also received on N.218. The most widely planted selection was N.197 which was consistently placed in classes 3 to 4 but usually failed to achieve the fine quality of N.39; this confirms results at Lyamungu. Neither N.5 nor N.205 were widely planted; in quality the latter was similar to N.197, while the results of the former more nearly approached those of N.39.

BREEDING

N.39 was introduced into a preliminary inter-selection breeding programme, which was commenced at the end of 1952. Early results of a cross with a tree of the Geisha variety have given promising results in terms of yield, vigour, and leaf rust resistance. Other selections of the 'N' series have been introduced into the programme more recently, and these include N.30 and N.205.

CONCLUSIONS

While the exact origins of some of the trees in the plot at Kilema Mission containing the earliest introductions of coffee to Kilimanjaro must remain in doubt, some valuable selections have been isolated and seed has been widely distributed to growers. The final selections are all bronze-tipped types and are capable of yielding well; a few have produced beans of a consistently high liquoring quality, which must be accepted as an inherent characteristic. Outstanding in this respect is N.39 which combines quality with high yield, given the right conditions; it's defect of a somewhat extended cropping season should be noted. N.197 has achieved comparatively high yields over a wide range of conditions, and N.205 is also promising in this respect although it has not been widely tested. N.218 is a good selection combining yield and quality; the quality of N.30 has been very good at Lyamungu but its yield was rather disappointing and it has not been tested elsewhere. There is some similarity between N.39 and N.5; although the yields of the latter may not be quite so favourable, its quality is good and it has been well reported upon from the Mbozi area.

The clone of N. 69 has not been tested at Lyamungu, but in view of the apparent success of the F1 generation and the yield of the three new selections located therein, further trials would be desirable, together with the progeny of N.197/90 and further selection of the N.39 progeny.

Based on the yields and quality reports of the 'N' series, it can be stated that neither high yields nor the best quality coffee were obtained at the higher

altitudes (5,300'—5,800') near the forest on S.E. Kilimanjaro. High yields can be obtained in the lower areas, without much loss in quality.

All the 'N' series are known to be susceptible to the important rust races endemic in E. Africa.

The use of N.39 in a limited breeding programme has resulted in some hybrids N.39 x VC.496, among others, exhibiting hybrid vigour and a high degree of rust resistance, as well as good yields during the first three bearing years.

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(2) GILBERT, S.M.—1941—A. R. Coffee Research and Expt. Station, Lyamungu, Moshi for 1939: P.6, Govt. Printer, Dar es Salaam.

(3) HAARER, A.E.—1930—Arabian Coffee. Pamph. 2. Dept. of Agriculture, Tanganyika, Govt. Printer, Dar es Salaam.

A COMPARISON OF THE MULTIPLE AND SINGLE STEM PRUNING SYSTEMS UNDER CONDITIONS OF LIGHT SHADE

By L. M. FERNIE, Horticulturist

The object of a particular pruning system is to modify the natural habit of the tree to suit the particular conditions under which it is grown. In the case of coffee the system is basically one of training with the purposes of increasing productiveness and facilitating the harvesting of the crop.

The Trial:

The first trial to compare systems of training *arabica* coffee at Lyamungu was planted in January 1936 as Experiment XIII. There were two initial methods of establishing the multiple stem system in this trial; one was by bending over the main stem (Agobiada), and the other by stumping; in each case three suckers were selected to provide 3-stems. Both these methods were compared with single stem and with each other. It was obvious at an early date that the Agobiada method as practised here retarded the development of the tree, and stems arising along the length of the bent-over main stem were progressively weaker than those arising near the base. This weakness is reflected in the yields shown in Tables V and VI. After the first cycle, the Agobiada method was not repeated, and the interest of the trial was centred on the comparison of multiple 3-stems and single stem, with which this paper is primarily concerned.

The experiment was laid out as a 3 x 3 Latin square, repeated three times in different parts of the station. The plots consisted of 12 trees, which were planted as two-year-old seedlings of the Kent variety selected for uniformity, especially girth; the plants were stumped back at the time of transplanting. Each square was planted with temporary shade of *Sesbania aegyptiaca* and with plants of the slow-growing *Albizzia maranguensis* as permanent shade. The former trees were short-lived and were uprooted after 7 years, while the establishment of the latter was erratic and uneven.

Yields:

A very small 'fly' crop only was harvested in 1938; in 1939 the crop was again small. Compared to present standards, yields throughout the 22 years of of the experiment have been low, 20 cwt./acre clean coffee having been exceeded only once (1947) for both the treatments under consideration. This must be attributed in part to the shaded conditions of the experiment and general management, but mostly to the material which was inevitably unselected at that time.

TABLE V

Experiment XIII—Annual yields for 22 years, expressed as cwt./acre clean coffee

Year	Single stem	Multiple 3-stems	Multiple Agobiada (3-stems)	Mean	S.E.	L.S.D. (P=0.05)
1938	0.34	0.22	—	—	—	—
1939	1.98	2.35	0.41	1.58	0.30	1.04
1940	3.00	11.93	6.61	7.18	0.49	1.71
1941	7.29	12.96	6.37	8.87	0.70	2.42
1942	3.99	12.03	7.49	7.84	0.40	1.39
1943	5.32	17.24	13.08	11.88	0.84	2.92
1944	5.32	5.68	4.99	5.33	0.13	0.44
1945	9.59	7.08	8.03	8.23	1.01	—
1946	1.04	2.30	0.90	1.41	0.31	1.26
1947	20.49	29.58	17.33	22.47	0.41	1.42
1948	9.32	5.06	10.99	8.45	0.76	2.64
1949	15.05	12.70	13.84	13.86	0.55	—
1950	10.01	13.45	6.43	9.96	2.10	—
1951	15.81	16.24	16.53	16.19	1.11	—
1952	11.35	10.01	10.20	10.52	0.78	—
1953	13.38	13.53	11.93	12.95	1.01	—
1954	13.15	13.83	12.27	13.08	0.74	—
1955	14.39	7.83	7.53	9.92	0.84	2.91
1956	17.85	19.27	19.77	18.96	1.36	—
1957	7.35	5.53	5.73	6.20	0.47	—
1958	5.62	5.29	4.52	5.14	0.28	—
1959	19.53	8.29	7.98	11.93	1.40	4.83
Mean (22 years)	9.57	10.56	8.79	9.64	0.26	0.88

An examination of the figures given in Table V shows that the differences in yield between the single stem and multiple 3-stems systems of pruning were highly significant in favour of the latter for each of the four consecutive years from 1940 to 1943 inclusive, during which time the single stem yields were admittedly poor. The first significant difference in favour of the single stem system did not occur until 1948, the eleventh year; thereafter yields were generally at a much higher level, especially that of the single stem, and the only years when further significant differences were recorded were in 1955 and 1959, again both in favour of single stem. By grouping the mean yields into 6-yearly groups (Table VI) it can be seen that the yield advantage of multiple stem has been in the first six years; for the next twelve years there is little difference between the two systems, and single stem has outyielded multiple stem over the last four years.

TABLE VI

Experiment XIII.—Mean yields in 6-yearly groups, expressed as cwt./acre clean coffee

	Single stem	*Multiple 3-stems*	*Multiple Agobiada (3-stems)*	*Mean*	*S.E.*	*L.S.D. (P=0.05)*
1938—43	3.67	9.66	5.66	6.26	0.28	0.98
1944—49	10.14	10.39	9.34	9.96	0.26	—
1950—55	13.02	12.49	10.81	12.11	0.31	1.07
1956—59	12.45	9.60	9.64	10.56	0.54	1.87
1938—59	9.57	10.56	8.79	9.64	0.26	0.88

This is demonstrated in a different way in Fig. III, where the running mean yields of 4-year periods are represented graphically. By this means the annual variations are smoothed out. It can be seen that the single stem system does

not out-yield the multiple stem until the 1948—51 period; but from 1951—54 onwards it has continued to do so. The narrowing of the gap between the two systems is clearly shown in the graph of the progressive means in Fig. IV.

It must again be emphasized that these results have been obtained under lightly shaded conditions, which are thought to favour the longevity of single stem trees; certainly, single stem trees under unshaded conditions have shown signs of deterioration elsewhere on the station after approximately 15 years. In order to assess the merits of the two systems without shade, and possible variations particularly in the methods of establishment, two further experiments (XXI and XXII) were planted in 1951 and 1953 respectively, but final results are not yet available.

OUT-TURN:

This is the ratio of clean coffee to cherry, expressed as a percentage, and it was derived from data obtained from plot samples. Reference to the graph in Fig. V shows that the out-turn from multiple stem trees was never less than that from single stem trees in any year from 1939 to 1952. The seasonal influence is marked, and both systems follow the same trend fairly closely in this respect. It is interesting to note that the out-turn ranges from 7.6% to 20.8% in the case of single stem, and from 7.6% to 22.2% in the case of multiple stem.

There is a tendency for the out-turn pattern to follow the yield pattern, the out-turn percentage rising when the yield increases, and falling when the yield is less. This is particularly true of the multiple stem system. It is true of both systems that, as the general level of cropping increased from 1946 onwards, the out-turn improved.

GRADE:

Determinations of the percentage of Grade 'A' in samples drawn from each system for certain seasons during the period 1939—50 showed that the multiple stem system invariably gave a higher percentage than the single stem. The results are summarised in Table VII.

TABLE VII

Percentage of Grade 'A'

	Single stem	*Multiple stem*
1939	66.9	73.1
1940	77.5	84.3
1945	83.2	85.7
1949	74.6	78.8
1950	76.7	83.4

QUALITY:

Samples of the 'A' Grade from each pruning system were submitted to a liquorer for a report and classification in each of the four years 1948 to 1951. The differences between the systems in this respect were so slight that they can be disregarded; seasonal differences were considerable, however. The classes achieved are shown in Table VIII.

TABLE VIII

Quality classification, expressed as commercial classes

	Single stem	*Multiple stem*
1948	1	1
1949	5	4
1950	3	3
1951	1	1

Summary and Conclusions:

Under the conditions of this trial, the yields from the single stem system were very low for the first seven bearing years and it was not until the tenth year that a yield exceeding 10 cwt./acre was recorded. The multiple stem trees, on the other hand, yielded well, but never excessively, from the third to the sixth year, and this initial advantage was still reflected as a significant difference in the mean after 22 years. From the tenth bearing year onwards, cropping was generally at a higher level especially on the single stem system, and the gap betwen the two systems narrowed, although differences in individual years were rarely significant. Thus, the yield advantage of multiple stem occurred in the early years, and it must be remembered that as a system it is always much cheaper and easier to manage.

The out-turn, expressed as a percentage of clean coffee to cherry, and the percentage of Grade 'A' were both in favour of the multiple stem system.

Quality tests showed no differences due to the pruning system.

FIGURE III

YIELDS AS RUNNING MEANS FOR 4-YEAR PERIODS

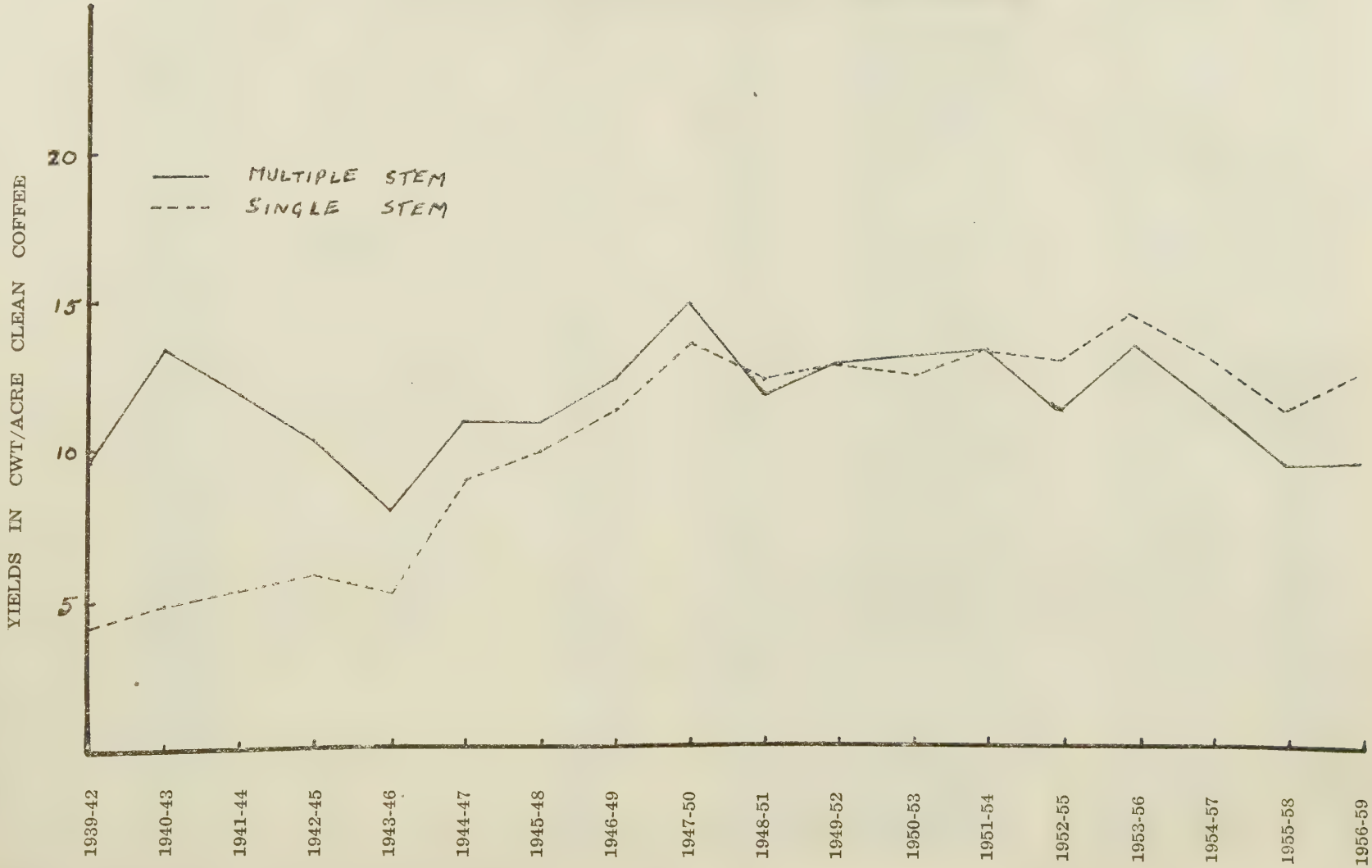


FIGURE IV

PROGRESSIVE MEAN YIELDS FOR 21 YEARS

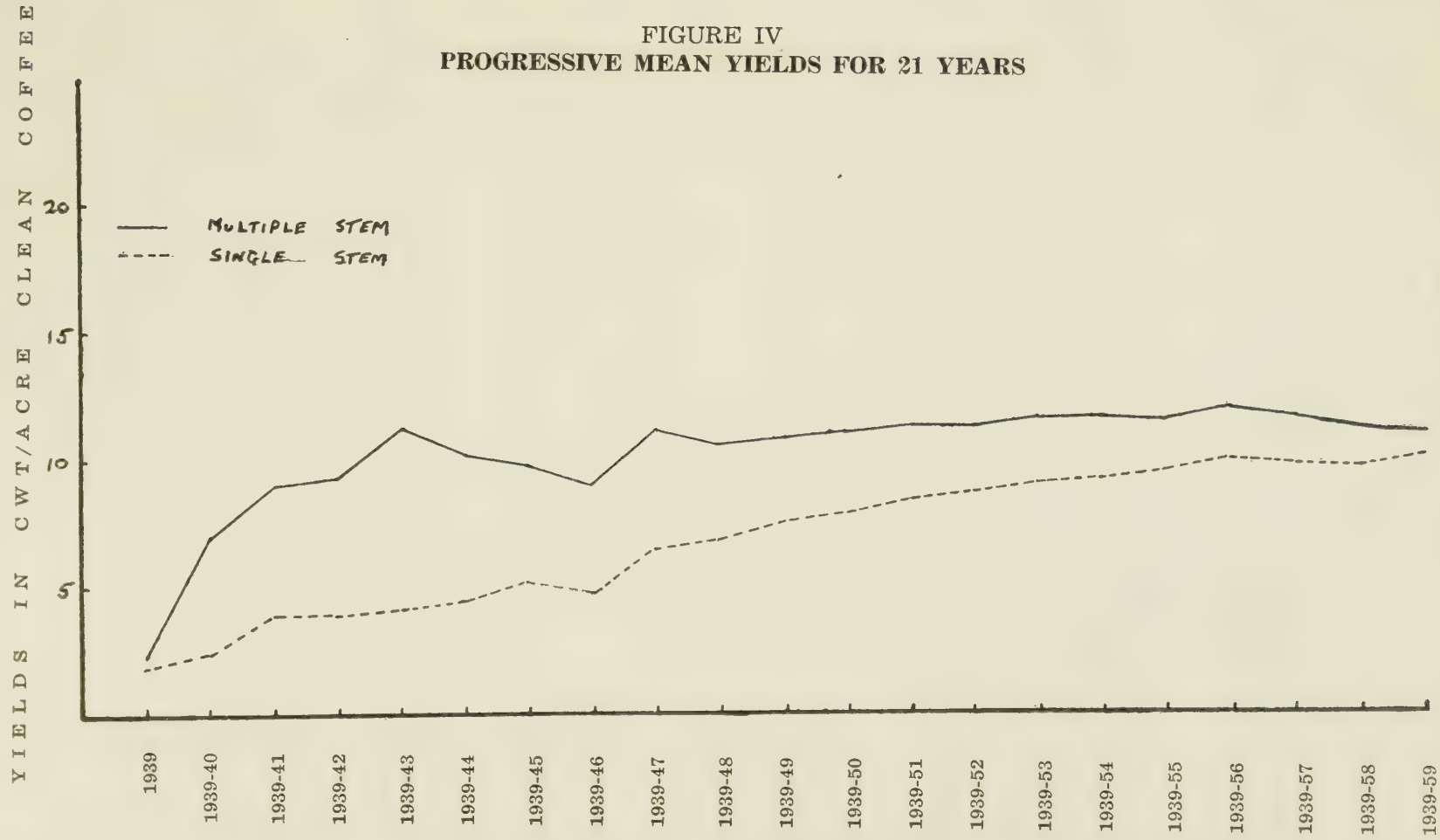
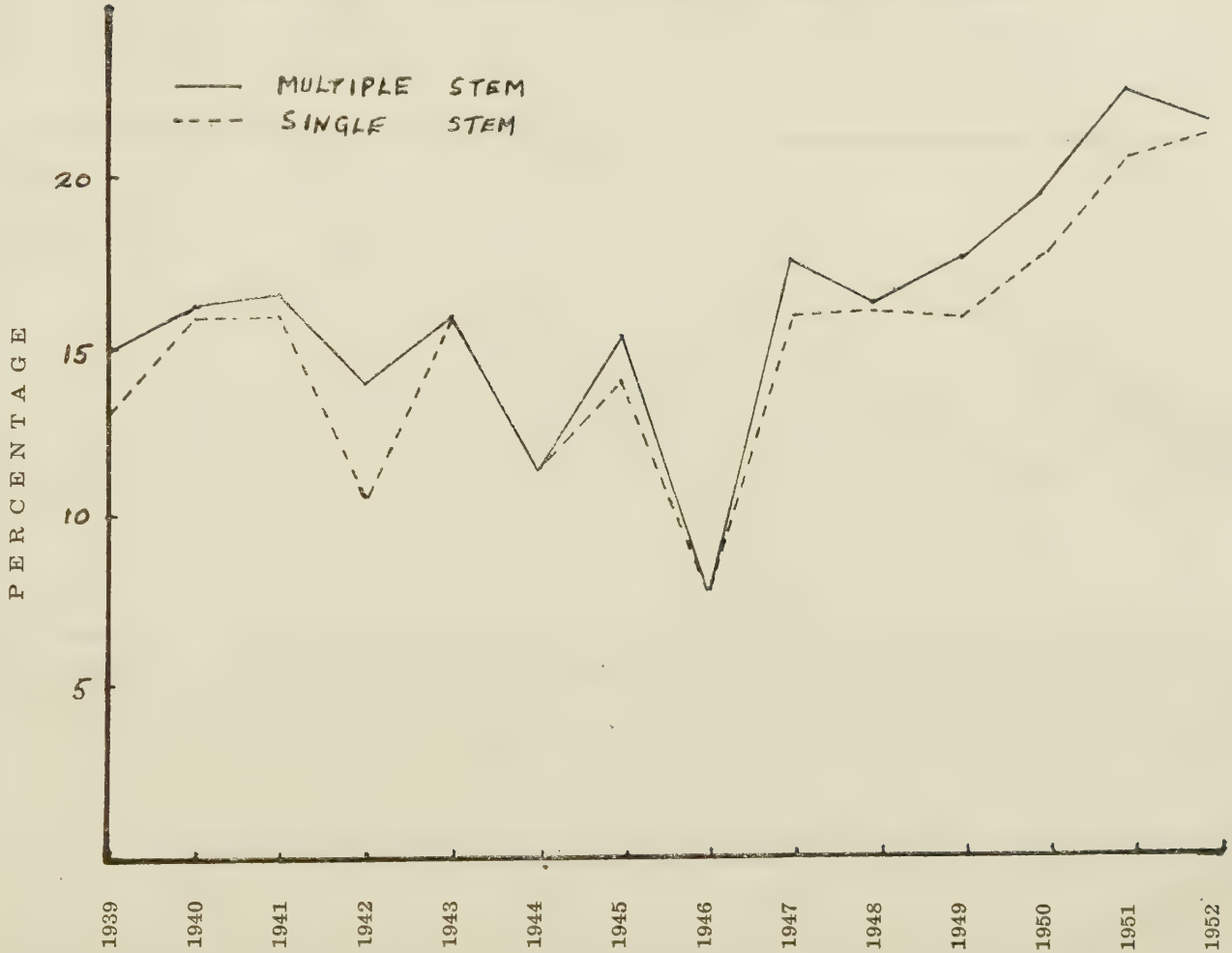


FIGURE V

PERCENTAGE OUT-TURN OF CLEAN COFFEE TO CHERRY



THE ACTION AND VALUE OF ORGANIC MULCHES ON THE YIELD AND NUTRITION OF THE COFFEE TREE

By J. C. WARDEN, Chemist

The use of a ground cover of dry vegetable matter such as grass, straw, or banana leaves has long been advocated for the successful growing of perennial crops under a dry tropical climate (1). The expected benefits include a reduction in the surface soil temperature and better maintenance of its moisture, the replenishment of the soil with necessary plant nutrients, a lessening of both weed growth and erosion hazards, and improvements in soil structure. Field experiments were laid down at the Coffee Research Station in 1940 to assess the value of mulching on the coffee crop, and the results have been reported from time to time in Annual Reports from this Station. Confusion remains, however, in the minds of many Tanganyika coffee growers about the action and economic value of mulches, and it is hoped that this summary will clarify the position.

1. The effect on the yield of Arabica coffee :

A full description of the three experiments laid down in 1940 to test the effect of mulches and related treatments on the yield of coffee will be found in earlier Annual Reports from this Station (1941—1956). Since many of these are out of print, however, an outline summary is given below.

Experiment XV:

Four mulch treaments and 4 irrigation treatments were compared, with 4 different clones used as replicates.

The mulch treatments (complete soil cover) were :—

1. Control (clean weeding).
2. 40 lb. banana leaf in June, post Long Rains application.
3. 80 lb. banana leaf in June.
4. 40 lb. banana leaf in June and 40 lb. in November.

The arrangement was a quasi-latin square; the coffee was unshaded and the trees were spaced 9 x 9 ft. square. Each plot contained 16 trees.

Experiment XIV A:

Banana leaf and two grass mulches were compared and the plots were split for the application of sulphate of ammonia. The main treatments were :—

1. Control—clean weeded as necessary.
2. Banana leaf at 80 lb./tree in June.
3. Guinea grass (*Panicum maximum*) 80 lb./tree in June.
4. Elephant grass (Napier grass, *Pennisetum*) 80 lb./tree in June.
5. Compost, 1 debe (4 gal.), prepared from 80 lb. elephant grass, per tree in June.

There were 5 replicates of each treatment. The coffee in this experiment was shaded and the layout was a 5 x 5 latin square with 20 tree main plots split into halves by a guard row. It is not proposed to discuss the interaction with fertilizer, which is the subject of a new experiment at present.

Experiment V:

This was a 3 x 3 x 3 factorial experiment in which 3 levels each of elephant grass, sulphate of ammonia, and compost were used as treatments. It is proposed to discuss here only the uncomplicated mulch treatments (partial, inter row,

Figs: VI VII and VIII. The mean annual yields of clean coffee, given in cwt. per acre, from the mulch and irrigation treatments of three field experiments, expressed as running mean yields for groups of six years and for a total period of 14 years.

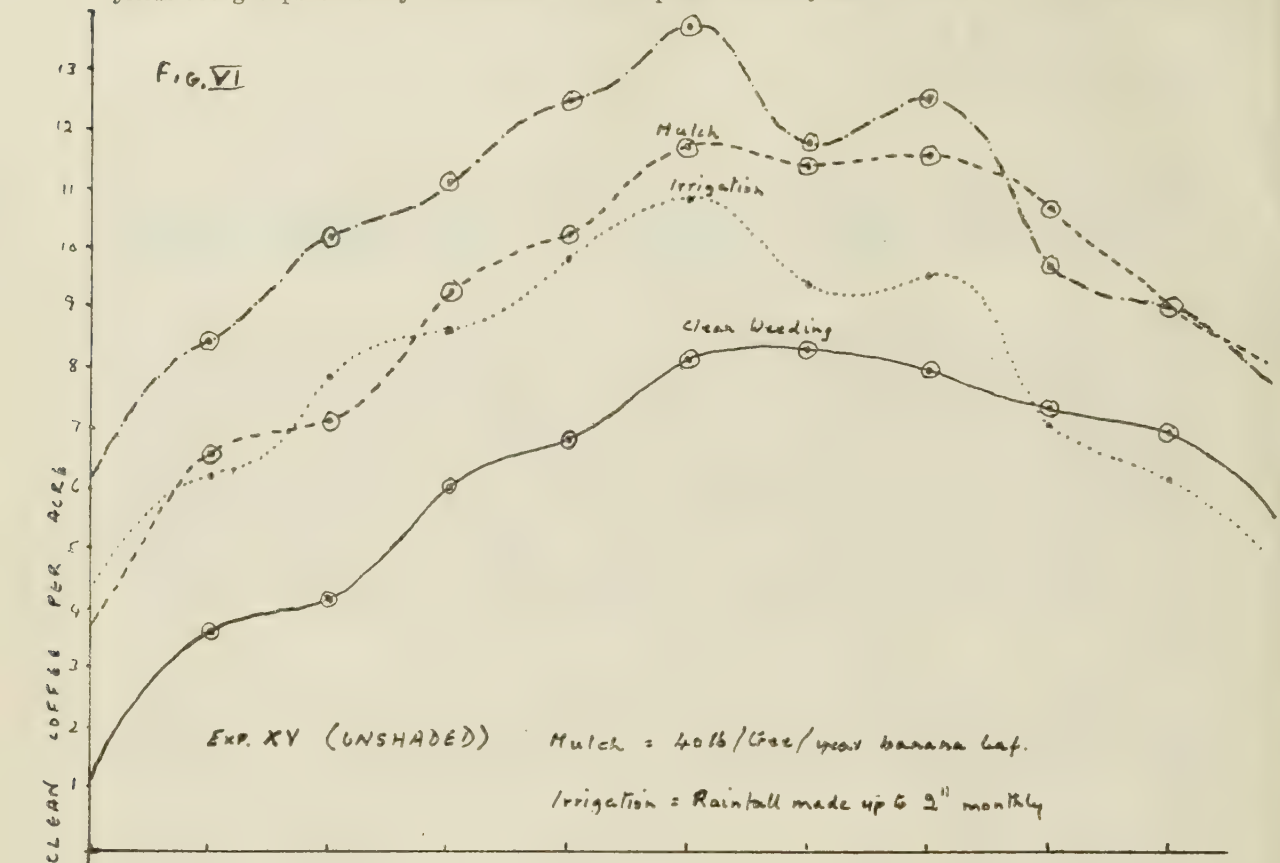
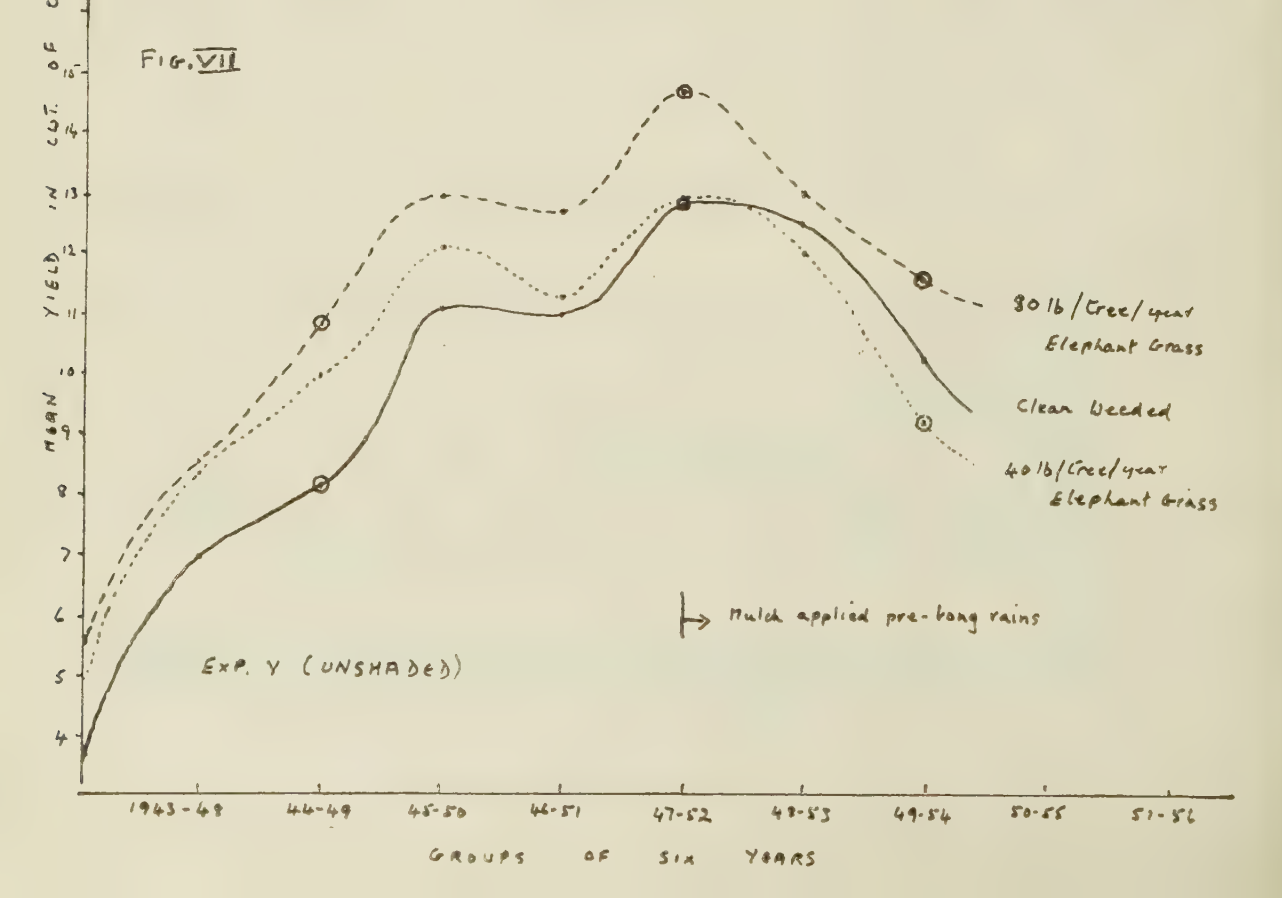


FIG. VI
Mulch
Irrigation
Clean Weeding
MEAN YIELD IN CWT. OF CLEAN COFFEE PER ACRE
Exp. XV (UNSHADED)
Mulch = 40 lb/tree/year banana leaf.
Irrigation = Rainfall made up to 2" monthly

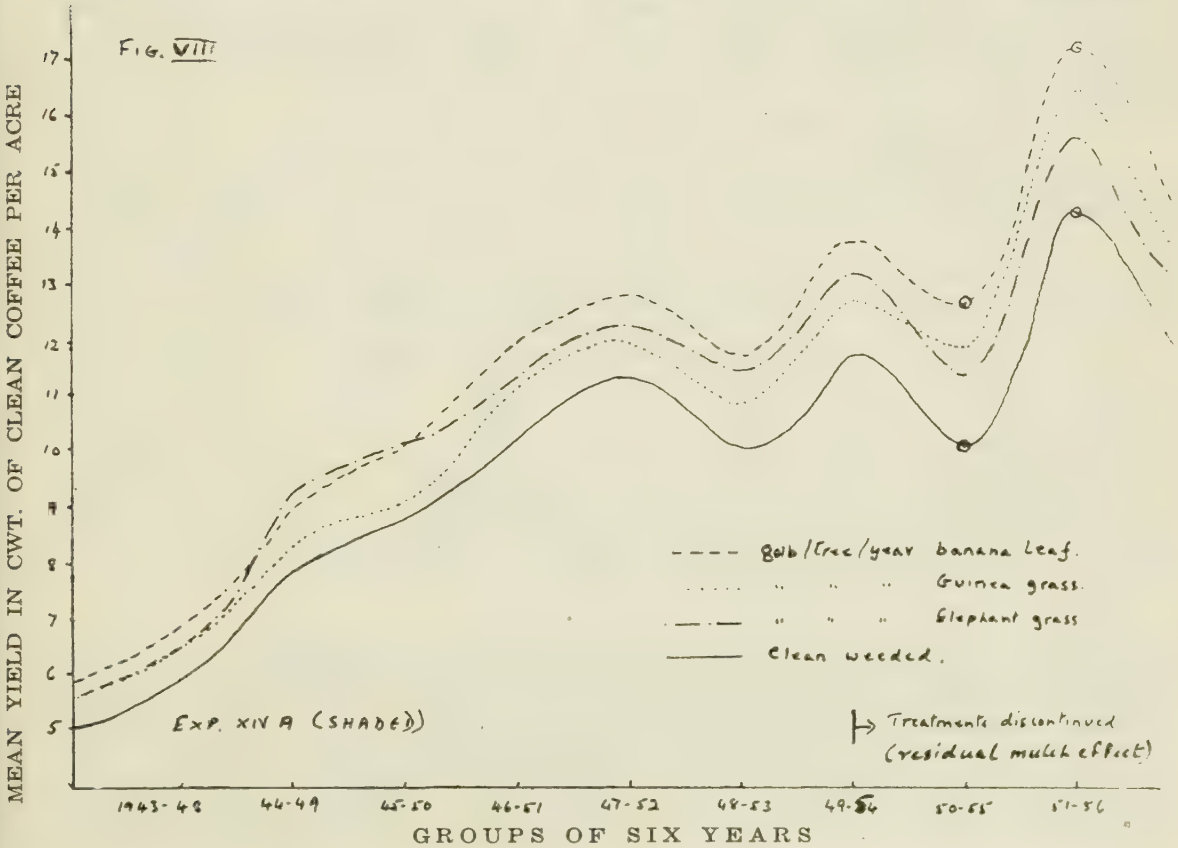


mulch cover). This is made possible by the fact that there were four replicates of each treatment plot. These plots contained 12 trees each, in unshaded conditions. While the "mulch only" treatments showed responses it should be mentioned that due to unfavourable interactions no significant overall response to mulch was observed, and in earlier reports the response in detail to mulch was not emphasised.

Discussion of the results of crop yields :

The results of these three experiments are shown (Figures VI, VII and VIII) in the form of running mean yields of clean coffee in six year periods. In this form the maintained separation of the yield curves for the different treatments is a measure of their significance, which can be appreciated visually. Where statistically significant differences have been reached in individual six year groups this is marked by circled dots; in Experiment XV all the points on the mulch curves represent statistically significant, generally very highly significant, responses.

While their beneficial effect is beyond dispute, the degree of response to mulches varies with location, type of mulch, and the weight applied. The large response in Experiment XV may be due in part to the rather poorer soil (cf. Footnote); banana leaf has shown itself the best of the mulches tried. It breaks down more slowly and may be of greater value in the retention of moisture. However, the residual effects obtained in Experiment XIV A point to soil amelioration.



The drop in value in Experiment V when the time of application was changed to before the Long Rains suggests that the greater benefit of the mulch may be one of moisture retention in the dry weather following the rains and this may in turn be due to the unshaded conditions and the rich soil. More evidence on the action of mulches will be found in Section 3. (Effect on leaf nutrient content)

The economics of mulch use will clearly vary from area to area. It will be greatest where rains are sparse and drought periods prolonged. Until a routine of frequent controlled irrigation can be introduced, its value should be rated very high. In the presence of irrigation it will serve to economise the water application and will continue to supply essential plant foods to the coffee.

All the experiments mentioned have involved a complete mulch cover except the 40 lb. mulch treatment in Experiment V which consisted of strip mulching. With due allowance for climatic differences, it is likely that where grass mulches are concerned a minimum effective density is needed, corresponding to a settled layer of about four inches.

A general point arising from Figs. VI, VII and VIII is the drop in yield which appears in the two unshaded experiments after the tenth crop. The suggestion is one of depletion of the soil, but no results are available on the state of the soil at the start of the experiment. On the other hand, in spite of the rapid drop in yield in the more heavily cropping, irrigated treatment in Experiment XV, no statistical difference was noted in the state of the soil between the control and irrigated treatments at the end of the experiment (cf. Section 2) and the likelihood of a physiological age factor remains.

From the crop yields alone it may be concluded that the application of banana leaf and grass mulches is economic in terms of increased production particularly where periods of drought are usual. The rate of application seems to be more critical for grass mulches than for banana mulch which is more persistent.

2. **Composition of the mulches used :**

Before referring to the table of results, it is relevant to inquire into the nutrient value of the mulches used. Some estimates of the added weights of nitrogen and potassium are given in Table IX.

TABLE IX

The addition of nitrogen and potassium to the soil as decomposition products of three organic mulches, based on analysis of the dry material. (Weight in lb./acre at 40 lb. mulch per tree, 9x9 ft. spacing.)

	Banana leaf	*Guinea grass*	*Elephant grass*
Nitrogen	258	365	—
Potassium	284	624	—
		486*	1290*

*Data estimated from Coffee Research Station, Ruiru, Kenya, (3) for local Kenya grasses,. Long Rains cut.

It can be seen that the addition of potassium is very high with an Elephant grass mulch.

3. **The effect on soil properties :**

Two of the experiments mentioned in Section 1 : Experiment XV and Experiment XIV A, were made the subject of a soil study on a statistical basis after 12 years of continuous mulching i.e. 11 crops. The soil at the Coffee Research Station, Lyamungu is a deep volcanic clay loam containing in places undecomposed fragments lo lava rock. Its structure is typical of a clay loam, but pockets are occasionally found which contain a higher proportion of clay, and this may effect the relative distribution of coffee roots. The moisture retaining properties are high : typical results from oven drying are 45—50% moisture at field capacity

and 10% at air dryness with wilting point at approximately 16%. The previous history of the land in these experiments is outlined in the footnote.

SAMPLING PROCEDURE:

The surface soil only was analysed. Samples were taken with an auger to 6 inches depth, several samples from each plot or sub-plot being combined to form one composite sample.

ANALYTICAL METHODS:

It is not proposed to describe these in detail. The organic carbon percent was obtained by the standard method of Walkely and Black, nitrogen by a Kjeldahl method, and pH was measured with a glass electrode on a 1:2.5 soil/water suspension. Exchangeable potassium and calcium were determined in ammonium acetate extracts, the first colourimetrically using sodium cobaltinitrite, and the second by a semi-micro ammonium oxalate/permanganate method. Some physical analysis was also performed on samples from Experiment XV to obtain evidence of any structural changes.

RESULTS:

The results of the investigation are shown in Table X.

TABLE X

The effect of 12 years application of different mulches on some properties of the Kilimanjaro clay loam soil at Lyamungu

Treatment	*%C*	*%N*	*pH*	*Ex.Ca mge%*	*ExK mge%*	*Water stable aggregates : 1.0mm*	*0.5mm*	*100mesh*	*% total pore space*
EXPERIMENT XV +									
Control	3.05	.296	6.68	15.07	2.23	7.0	22.8	56.8	63.6
40 lb./tree	1.17	.057	0.57	5.09	2.32	5.5	9.3	3.2	1.6
80 lb./tree	1.56	.103	0.56	9.37	2.29	6.1	13.0	6.3	2.7
40 + 40 lb./tree	1.73	.115	0.52	8.93	2.47	6.0	10.3	7.0	4.2
Statistical level of significance	1%	1%	1%	1%	1%	5%	5%	5%	1%
EXPERIMENT XIV A. +									
Control	3.98	.420	6.53	19.51	2.73				
Banana leaf	.81	.078	.19	5.11	.73				
Elephant grass	.48	.016	0	0	1.29				
Guinea grass	.66	0	0	0	.72				
Compost	0	.040	0	0	0				
Statistical level of significance	5%	5%	5%	5%	5%				

NOTE: 1. For greater clarity, the results other than those of the control plots, are represented as significant positive increments.

2. + Experiment XV — Banana leaf mulch only, unshaded coffee.
Experiment XIVA — Mulches at 80 lb. per tree, compost 1 x 4 gallon tin per tree, shaded coffee.

The soil properties vary slightly between the two areas; the site of Experiment XIV A (shaded coffee) being the richer in all chemical properties (cf. footnote), but having a slightly lower pH value. It should, perhaps, be emphasised that these results represent a comparison between the state of the soil plus and minus the mulch treatments, after twelve years of coffee cultivation.

The most pronounced chemical effect is that of banana mulch on the exchangeable calcium, and the final calcium content under the same mulch treatments in the two experiments is very similar.

Potassium was substantially increased under the mulches; Elephant grass was the most effective treatment in this respect (Experiment XIV A) as expected from the potassium content of this grass, (Table IX). Banana mulch was however, very effective on the poorer soil of Experiment XV.

With respect to all other chemical properties, banana mulch was the most effective treatment, and this is reflected in the yield results (Fig. 3.). It is worth mentioning that nitrogen was increased under mulch by a greater amount in the richer soil, but that pH and exchangeable bases were less affected.

Improvements in the structural properties were also found to result from treatment with banana mulch, the size of water-stable aggregates of the soil being increased over three size ranges, as also was the pore space. No data for this comparison between the grass and banana mulches is avaliable although work carried out elsewhere on a similar type of soil confirms that Elephant grass mulch produces the same type of effect on soil structure, (7).

To summarise, banana mulch had the most profound effect on the chemical properties of the soil with the exception of exchangeable potassium, and little further benefit was shown to result from increasing the minimum weight of 40 lb. per tree.

Irrigation was found to have no significant effect on soil properties, and these results have been omitted from Table X.

4. The effect of mulch on leaf nutrient content :

The large yield responses obtained by mulching in Experiment XV stimulated an investigation of the monthly variation in the leaf content of the major cationic nutrient elements i.e. potassium, calcium, and magnesium. This investigation was carried out between September 1954 and July 1956, inclusive.

METHOD OF SAMPLING:

Young (first fully mature) leaves were chosen for analysis. Subsequent work in Costa Rica has shown that leaves taken from the cropping nodes of the branch provide a more critical appraisal of the nutritional condition of the cropping tree with respect to the major elements other than calcium (4), but interesting results were nevertheless obtained. The treatments chosen for study consisted of the control, all the mulch only treatments, and the lowest irrigation treatment in the presence and absence of mulch. Leaves from all four plots of each treatment were sampled each month and bulked to form one sample of about 100 leaves. The analytical work involved prohibited any replication.

RESULTS AND DISCUSSION:

The mean monthly leaf concentrations of potassium, calcium, and magnesium for the two year period will be found in Table XI. For reasons which will be apparent later only the clean weeded treatment and the lowest level of mulch are initially discussed.

FOOTNOTE:

Note on the early history of the experimental land:

The experiments mentioned above were some of the earliest to be laid down on the Research Station, and the following data are relevant to Sections 1 and 2:—

Experiment XV was laid down on cleared land, part of which had previously been under Ceara rubber (*Manihot glaziovii*). This is known to be a demanding crop. The land was subjected to some considerable disturbance by levelling.

Experiments V and XIV A were originally under *Vernonia-Clerodendron* bush community and were planted out with *Tephrosia vogellii* (a green manure) for the year previous to coffee planting.

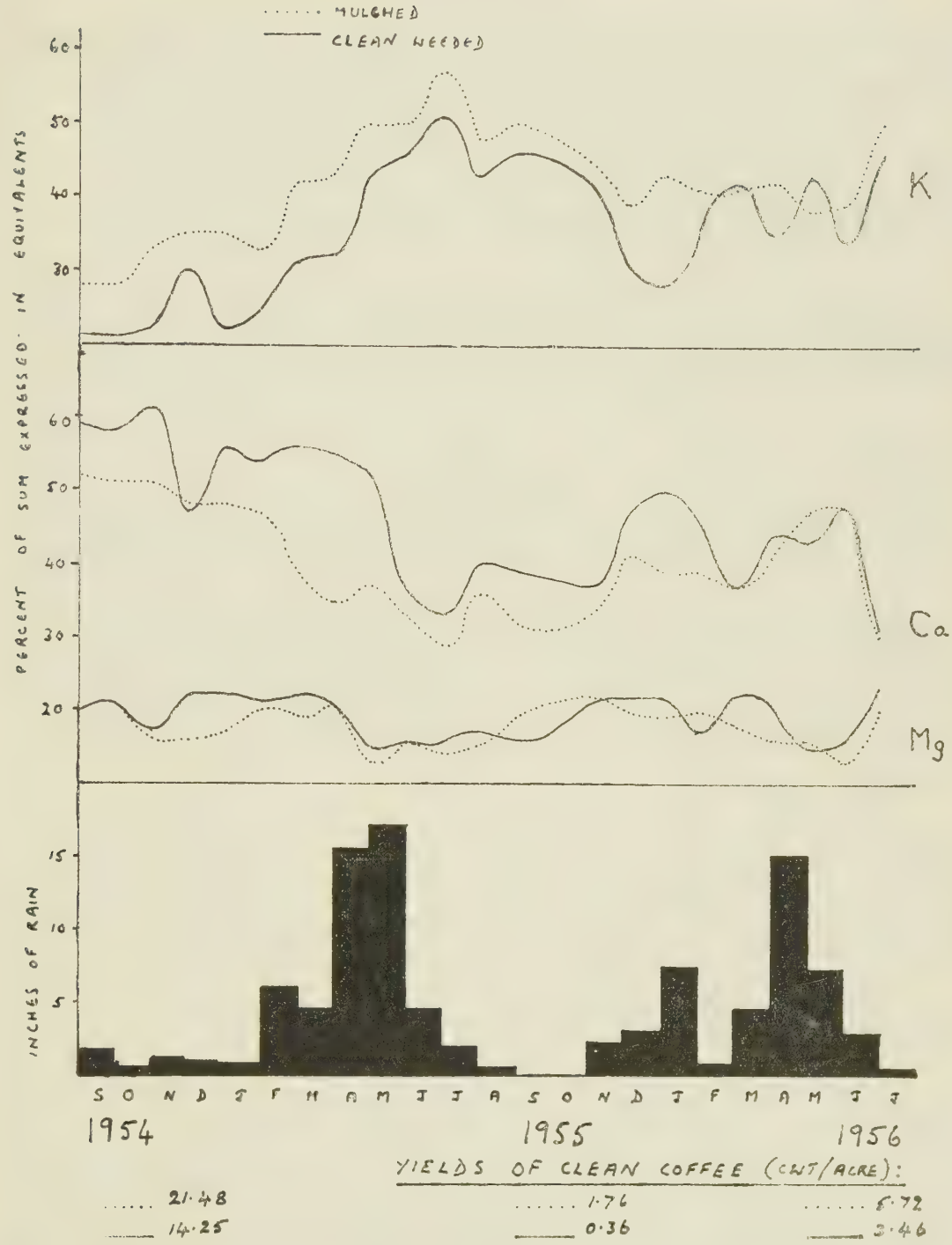


Figure IV.—The relative proportions in the first fully mature leaves of coffee trees of potassium, calcium, and magnesium, in the presence and absence of a complete soil cover of 40 lb. per tree per year of banana leaf mulch and relationship to yield and rainfall over two years.

TABLE XI

Mean leaf concentrations of potassium, calcium and magnesium in mulched and unmulched coffee between September 1054 and July 1956

First pair of fully mature leaves : meq. % dry matter	*Potassium*	*Calcium*	*Magnesium*	*Sum*
Clean weeded	50.8	67.4	28.3	146.5
Banana leaf at 40lb./tree	62.7	62.6	27.5	152.8
% difference	+23%	—7%	—3%	+4%
Statistical level of significance	5%	NS	NS	NS

Due to the lack of replication the results are not capable of being analysed very accurately, but nevertheless potassium appears to have been raised in the leaf by a significant amount over the two year period by the mulch treatment. Calcium and magnesium are reduced, but by a less than proportional amount, and it is likely therefore that their uptake is not impeded over the season as a whole.

Seasonal fluctuation is best illustrated when the elements are plotted in equivalents as fractions of their sum, (Fig. IX). As well as emphasising any differences in concentration ratio this method has the advantage of reducing slightly the analytical error. In Figure IX the differences brought about by treatment are clearly shown in the case of potassium and calcium, and are consistent over and above the seasonal fluctuation. There is as well, however, a tendency towards a levelling out of the seasonal fluctuation in the mulched plots.

Reciprocal uptake of potassium and calcium in plants which are subject to periods of drought has been found by other workers, and a review of the literature will be found together with other work in this connection undertaken at this Station in another publication (5). It is likely therefore, that this levelling out is a result partly of better soil moisture conditions under mulch. If, however, the availability of potassium to the plant is the overall determining factor, then the increase in exchangeable potassium in the soil (refer Section 2.) must play a large part.

The mulch treatment appeared to have a small effect only on the magnesium concentration, but the minimum seasonal level in both years was depressed slightly. The minimum point occurred in both years in the second half of the rainy season. This suggests that magnesium deficiency would be made more serious by mulching with banana leaf in places where the soil has a low exchangeable magnesium, or where potassium nutrition is at a high level, and this finding would seem to accord in general with that of Robinson and Chenery (6).

There is a strong suggestion from Figure IX that the improvement in potassium nutrition brought about by the mulch was responsible for the considerable yield increases in the years concerned.

For the sake of clarity, and because they are felt to be the most important, only the clean weeded treatment and the lowest level of mulching have been discussed in detail. The overall importance of the latter treatment is confirmed by the yield responses and the soil analysis (Sections 1 and 2). The findings from the other treatments studied will be summarised briefly. Irrigation was found to raise the level of potassium nutrition, but rather less consistently than the mulch treatment discussed. Little additional improvement was found in the higher banana mulch treatment, and in view of the findings of Sections 1 and 2 these results are of less interest. The results from the irrigated and mulched plots varied little from those of the mulch treatment discussed.

CONCLUSIONS

1. Organic mulches have increased the yield obtained from arabica coffee. The increase greater in unshaded than in lightly shaded coffee on the same soil type.
2. Organic mulches and particularly banana trash, have been shown to improve the physical structure of the soil and its chemical fertility. Increased uptake by the coffee tree of potassium in the presence of a mulch is shown by analysis of the leaf.
3. Based on these results and the results of research elsewhere in East Africa, the application or organic mulch to coffee is recommended for increased crop production. A partial soil cover is preferred as a pre-rains application i.e. in the tree row or in the inter-row, which may be topped up to a complete soil cover after the main rains are over. This avoids the chance of seasonal temporary waterlogging during periods of frequent and heavy rain fall.

ACKNOWLEDGEMENT

The original investigations into the soil conditions and leaf nutrition in these mulch experiments were the work of Mr. L. J. Hart, who was the chemist at the Coffee Research Station from August, 1952 to March, 1957.

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EXPERIMENTS AND OBSERVATIONS ON THE CONTRIBUTION OF A DRY TOPSOIL TO MINERAL DEFICIENCIES IN THE COFFEE TREE

By J. C. WARDEN, CHEMIST

A. Studies by foliar analysis

1. Association of Mineral deficiencies with overbearing.

Perhaps the most striking phenomenon associated with the physiology of the **arabica** coffee tree, and one which makes coffee cultivation so peculiarly different from that of most other perennial plants, is the capacity of the tree to overbear. This capacity is associated with the removal of the tree from its natural environment under the dense shade of tropical forests and the consequent increase in stimulus of direct sunlight, and the higher temperature.

The ripening of a heavy crop demands a very large reserve of starch which often the tree does not possess, and in these circumstances the leaves will turn yellow and fall off. Analysis of the leaves at this time reveals a very low content of all the major plant nutrients, usually with the exception of calcium. Calcium is needed only in a relatively small proportion in the crop, (1).

The following data (Table XII) illustrate the condition of some unshaded coffee trees on this station in July, 1959.

TABLE XII

Leaves from the non-cropping part of the branch of unshaded coffee trees in July 1950. (C. R. S. Lyamungu)

	N	*P*	*S*	*K*	*Ca*	*Mg*
Selected healthy leaves	2.64	0.14	0.23	2.03	1.92	0.30
Better trees in Expt. XXVII	2.78	0.12	0.25	1.73	1.08	0.34
Yellowing trees Expt. II (1)	1.93	0.06	0.15	0.85	1.86	0.32
Yellowing trees Expt. II (2)	1.76	0.08	0.14	1.08	1.26	0.28

NOTE : The analyses were single determinations of bulk samples for a tentative diagnosis of the condition of the trees. (19).

More recent work by Müller (2) has shown that during the ripening of the crop, mineral deficiencies of the major elements other than calcium are first exhibited in the leaves on cropping nodes and only in cases of severe malnutrition are they exhibited (as above) in the younger leaves.

Earlier work, e.g. Beckley (3) Pereira and Jones (4), French and Beckley (5), Rayner and Pereira (6, 7) has been more concerned with the presence and absence of starch and related nitrogen deficiency, but more recently Culot and van Wambeke (8), and Muller (21) have drawn attention to deficiencies of the other major elements, particularly potassium.

2. Mineral deficiencies at other times of the year

After the crop has been removed (November—December at Lyamungu) there is a period of apparent physiological inactivity of the coffee trees which ends when flowering is stimulated by the advent of the Short Rains or by irrigation.

If the crop is removed late, this period may be very brief and at present little information is available about how important this period is to root recovery and the rebuilding of reserves of starch.

Generally, yellowing trees recover their green colour after the crop is removed and symptoms of leaf mineral deficiencies of the major elements are not visible for a time. There is a flush of new growth, however, brought out by the Short Rains (at the same time as flowering) and microelement deficiency symptoms, zinc, iron, an d manganese, are often seen. These are seasonal and not normally serious.

In the long dry period between the Short Rains (January) and the Long Rains, which start at the beginning of April, yellowing of the leaves and other more characteristic deficiency symptoms of the major elements are quite usual, even with ad hoc sprinkler irrigation which is currently a common practice.

The data in Table XIII represent the results of leaf analyses performed in the course of advisory visits to estates on the lower slopes of Mt. Kilimanjaro, including blocks at this Station, in February, 1960. They all represent results of duplicate determinations on bulk samples of 25 or more leaves from at least 10 trees. Further details of sub-sampling and analysis will be found in the appendix to this section.

TABLE XIII

Mineral content as % in dry matter of representative leaf samples from different areas on the lower slopes of Kilimanjaro, during a dry period in 1960.
2nd pair of leaves with cherry in the axil

Date of Sampling	*Locality and condition of trees*	*Shade*	*N*	*P*	*K*	*Ca*	*Mg*
16th February	C.R.S. Expt. 26 Yellowing trres.	—	**1.57**	.15	**.70**	1.36	.21
16th February	C.R.S. Expt. 27 Yellowing trees.	—	**1.72**	.09	**.72**	1.76	.22
16th February	C.R.S. Expt. 22 Trees with "drooping leaves.	—	2.32	.09	.82	1.18	.23
Lower Masama district 16th February	Yellowing trees.	*	**1.85**	.17	**.92**	1.59	.15
Lower Masama district 16th February	Slightly Yellow trees.	*	2.42	.11	.84	1.77	.35
29th February ... ... Weru-weru district A.	Yellowing trees.	—	2.15	.15	1.86	1.37	.17
Weru-weru district A. 29th February	Slightly yellow trees.	—	**1.33**	.11	**.89**	1.36	.19
Weru-weru district A. 29th February	Very yellow trees.	—	**1.62**	.12	**.77**	1.39	.15
Weru-weru district B. 29th February	Slightly yellow trees.	—	2.25	.09	1.95	1.48	.13
Sanya Juu district 4th March	Slightly yellow trees.	—	2.63	.27	2.48	1.21	.13

Note: * Patchy shade. Figures in heavy type represent levels considered to be less than adequate.

It appears from Table XIII that suboptimal levels of the major nutrient elements are very prevalent during the dry period between the Short and the Long Rains. For further information on normal levels of these elements in coffee trees see Loué (9), Culot and Van Wambeke (8), Müller (21), Robinson and

Chenery (10). Levels of serious deficiency, however, are only apparent in the case of nitrogen potassium and magnesium; the latter, being mostly found in specific localities.

It appeared probable from the results of Table 2 and related observations that a possible reason for the malnutrition might be the dry state of the soil, particularly the more fertile topsoil, in which the bulk of the feeding roots of the Arabica coffee tree are found, Nutman, (11).

3. Deficiencies more particularly related to dry soil conditions.

Towards the end of January, 1960 a certain condition of the trees became very noticeable on the Coffee Research Station. The leaves adjacent to cherry clusters hung vertically (as though the tree were wilting) and tended to bend backwards towards the trunk. In the worst affected trees the older leaves developed autumnal tints. The condition was most noticeable in the tops of multiple stem trees (which bear single primary branches). The symptoms were tentatively diagnosed as those of a deficiency of phosphorus, Loué (9), Robinson (12), although the soils were thought to be sufficiently rich in available phosphorus for good coffee cultivation; it was known that this element is not needed in large quantities for the crop Van Dierendonck (13), Robinson (1).

A study was made of the leaf content of nitrogen, phosphorus, and potassium of multiple stem trees in two adjacent blocks on the station. (Exp. II and Exp. M.E. II). Twelve individual trees were selected, six of which showed the symptoms described in a severe form and six which were either free of the symptoms, or showed them only mildly. Ten leaves of the 7th node were picked from primaries on both the tops and the skirt of each tree; 4 samples of the topsoil (0-6") were also taken from beneath each tree and mixed to form one sample per tree, to observe any correlation between soil and leaf. The results of this study are shown in Table XIV.

(For methods of analysis see APPENDIX).

TABLE XIV

Phosphorus deficiency in bearing multiple stem coffee trees in hot dry weather, Coffee Research Station Lyamungu, January 1960. Clean cultivation, %P in dry matter of 7th leaf pairs.

Trees showing symptoms		*Healthy trees*			
1	2	3	4		
Top branches	Bottom branches	Top branches	Bottom branches	% reduction 1 : mean of 2,3,4.	Sig. at.
N % **1.63**	**2.26**	2.33	2.28	29 %	1 %
P % **.07**	**.17**	.15	.18	59 %	1 %
K % **.75**	**.96**	.84	.86	16 %	1 %

NOTE: Figures in heavy type represent levels considered to be sub-optimal.

Table XIV shows that the symptoms could be very largely accounted for by deficiencies of potassium and phosphorus, although nitrogen was significantly lower in the trees exhibiting the symptoms. Since there was negligible difference in the available phosphorus in the topsoil i.e. 20.7 ppm P healthy trees compared with 21.8 ppm P in deficient trees, the condition of the trees was ascribed tentatively to the reduced ability of a poorer feeder root system in these trees to extract phosphorus from the dry soil. (The study cannot be described as conclusive, since only the topsoil was analysed).

Further relevant studies by leaf analysis

The contribution of mulch to the nutrition of the coffee tree is discussed in another section, see page 25. Mulch effects a large improvement in the potassium nutrition of local coffee trees and from the results discussed above (Table XIV), some contribution to enhanced nutrition may be expected from the increase in available topsoil moisture.

A greenhouse experiment was devised to study the effect of soil moisture on the mineral nutrition of seedlings, and the detailed results of this work are being published elsewhere, (14). It was found that in the presence of adequate moisture for turgidity, dry soil conditions resulted in a generally lower level of major elements in the leaf. When, however, the plants were wilting a reduction in the uptake of phosphorus and potassium was found. Relative to potassium the calcium uptake was increased and the magnesium uptake was largely unaffected.

A study of the nutrition (by monthly foliar analysis) of lightly bearing and heavily bearing groups of coffee trees in the field is also discussed in the publication of the greenhouse experiment. In a study by leaf analysis, of the chemical nutrition of lightly versus heavily bearing groups of coffee trees, it was found that the ratio of potassium to calcium in the young leaf was related in a marked way to rainfall and crop yield. Following a heavy crop an increase in the ratio depended upon the incidence of rain.

Conclusions from the results of foliar analysis

The work described suggests that dry soil conditions and particularly a dry topsoil, is partly responsible for the poor nutrition of coffee trees in hot, dry weather. This condition is present between the Long and the Short Rains, and to some extent during the ripening of the main crop. While trees with good turgidity may have low leaf contents of all the major nutrient elements, trees which have poor root systems overall, and which might therefore have a reduced uptake of water, may be expected to show reduced leaf contents of phosphorus, in particular, and also of potassium. This is reflected in the common occurrence of visual phosphorus deficiency leaf symptoms in periods of dry weather.

4. Soil Moisture studies :

In conjunction with these studies by leaf analysis, an attempt was made to measure the soil moisture in situ under coffee trees growing in unshaded, and clean weeded conditions and under irrigated, mulched conditions in the same block. (C.R.S. Experiment XXII). Two similar plots of single stem trees were selected from this experiment which is designed to study the effect on coffee yields of these treatments.

Conditions of cultivation:

The trees were planted in 1953 and comprised a selection of a number of different seedling varieties. The mulch treatment consists of 40 lbs. dry banana trash per tree applied in March each year as a continuous cover.

Irrigation was applied to the treated plots by hose pipe; the water was directed into shallow basins around each tree. At the start of the study period (September, 1959) irrigation was applied in doses of 40 gallons per tree (calculated as approximately equivalent to 2" rain) whenever it was felt to be required and the September and November applications were therefore arbitrary. Later, however, an effort was made to use the readings from buried gypsum blocks as a guide to the time and amount of water being applied to keep the top

three feet of the soil profile as near to field capacity as practicable. This was far from successful (although practical experience increased over the year) due to the rapid rate of loss of moisture and because of a time lag between the gypsum block reading and the soil moisture tension.

THE MEASUREMENT OF SOIL MOISTURE:

In September, 1959 gypsum blocks (cylindrical type manufactured by Baird and Tatlock) were buried at 6", 12", 24", and 36" under different trees in each of the two plots selected to represent different ground treatments. They were buried 3 feet from the stems of the trees along the diagonal between trees, and in random directions. In January, 1960 the 12", 24", and 36" blocks under the irrigated trees were duplicated, since it was felt that some error could arise from a variable spread of irrigation water. The electrical resistance of these blocks measured in log ohms is nearly a linear function of soil moisture tension.

Gypsum block readings were taken twice a week and plotted, together with rainfall and irrigation, in the form of histograms. Figure X shows a part of the graph and illustrates the rapid rate of drying of the clean weeded soil and the effect of two irrigation applications on the gypsum block readings.

CALIBRATION OF GYPSUM BLOCKS AND THE DETERMINATION OF WILTING POINT:

Two experiments were conducted to find the gypsum block reading on local topsoil samples indicating the first permanent wilting point. The results were not sufficiently precise to warrant inclusion here but observations showed that grasses and a coffee seedling began wilting at a gypsum block reading of about 4.5 log ohms.

The blocks were calibrated in duplicate against the soil moisture content of samples of soil taken from the plots concerned at the appropriate depths. While the moisture percentage is a value of less interest than the moisture tension, the calibration curves serve to indicate the range of precision of the readings and the approximate values at air dryness and field capacity. The mean of the duplicate readings have been plotted in Figure XI for different soil depth samples.

DISCUSSION OF THE RESULTS OF THE SOIL MOISTURE STUDY:

It is apparent from Figure X that the top three feet of soil in clean weeded unshaded coffee conditions dries out to a level approaching or exceeding wilting point in hot dry weather, and this study serves to corroborate the impressions resulting from foliar analysis described in section 3, i.e. about the importance of soil moisture to the nutrition of the coffee tree.

In Figure XII the mean of all the readings to 3 feet has been plotted for the two soil treatments (clean weeding versus mulch plus irrigation) from the start of the study to the beginning of the long rains in 1960. It is interesting to see that the irrigation and mulch treatment reduced the soil moisture tension to approximately half that under bare soil over the whole period. Since the soil moisture tension is proportional to the energy of removal of water from the soil, the energy needed in water removal was approximately halved by mulch and irrigation.

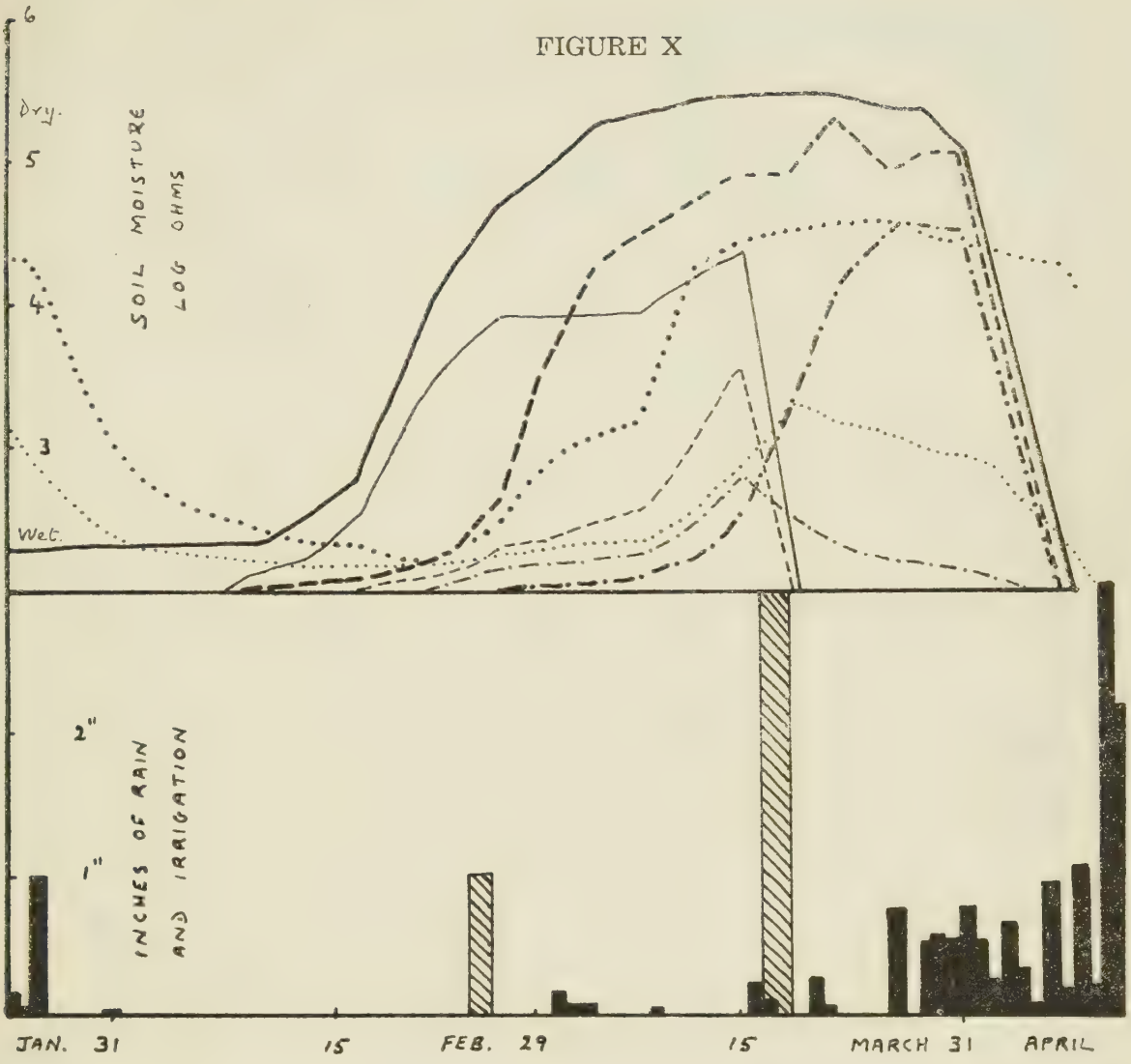
The study has not yet continued long enough for the association with crop yield to be determined.

APPENDIX

METHODS OF FOLIAR ANALYSIS:

Samples of leaves were dried at between 60° and 80° C, milled to pass 40 B.S. mesh bolting cloth, and thoroughly mixed. Sub-samples were dried at 105°C for moisture correction, and further sub-samples were taken for analysis.

FIGURE X



CLEAN WEEDED, NO IRRIGATION.

MULCH + IRRIGATION.

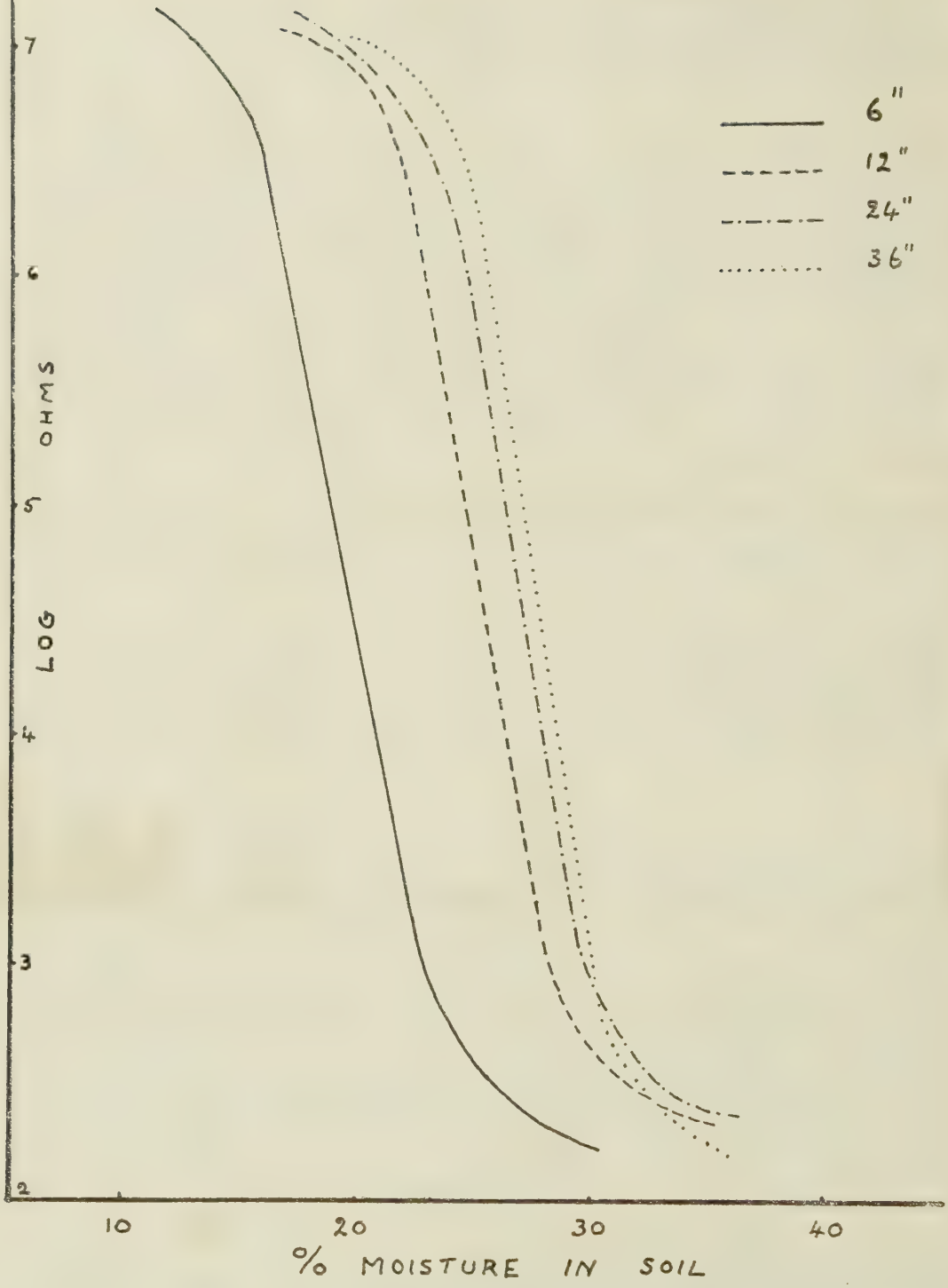
———	6"	DEPTH OF	——— 6"
- - - -	12"	BURIED	- - - - 12"
· — · —	24"	GYPSUM	· — · — 24"
· · · · ·	36"	BLOCKS	· · · · · 36"

RAINFALL, IRRIGATION, AND SOIL MOISTURE
Between the short and long rains 1960.
Coffee Research Station, Experiment XX11.

RAIN

IRRIGATION

FIGURE XI



CALIBRATION OF GYPSUM BLOCKS WITH % SOIL MOISTURE.
SOIL AT DIFFERENT DEPTHS IN PLOTS IN EXPERIMENT XX11.
(MEANS OF DUPLICATES)

RAINFALL, IRRIGATION, AND SOIL MOISTURE. SEPT 1959 - APRIL 1960.
MEAN OF READINGS OF BLOCKS BURIED AT 6", 12", 24", AND 36".

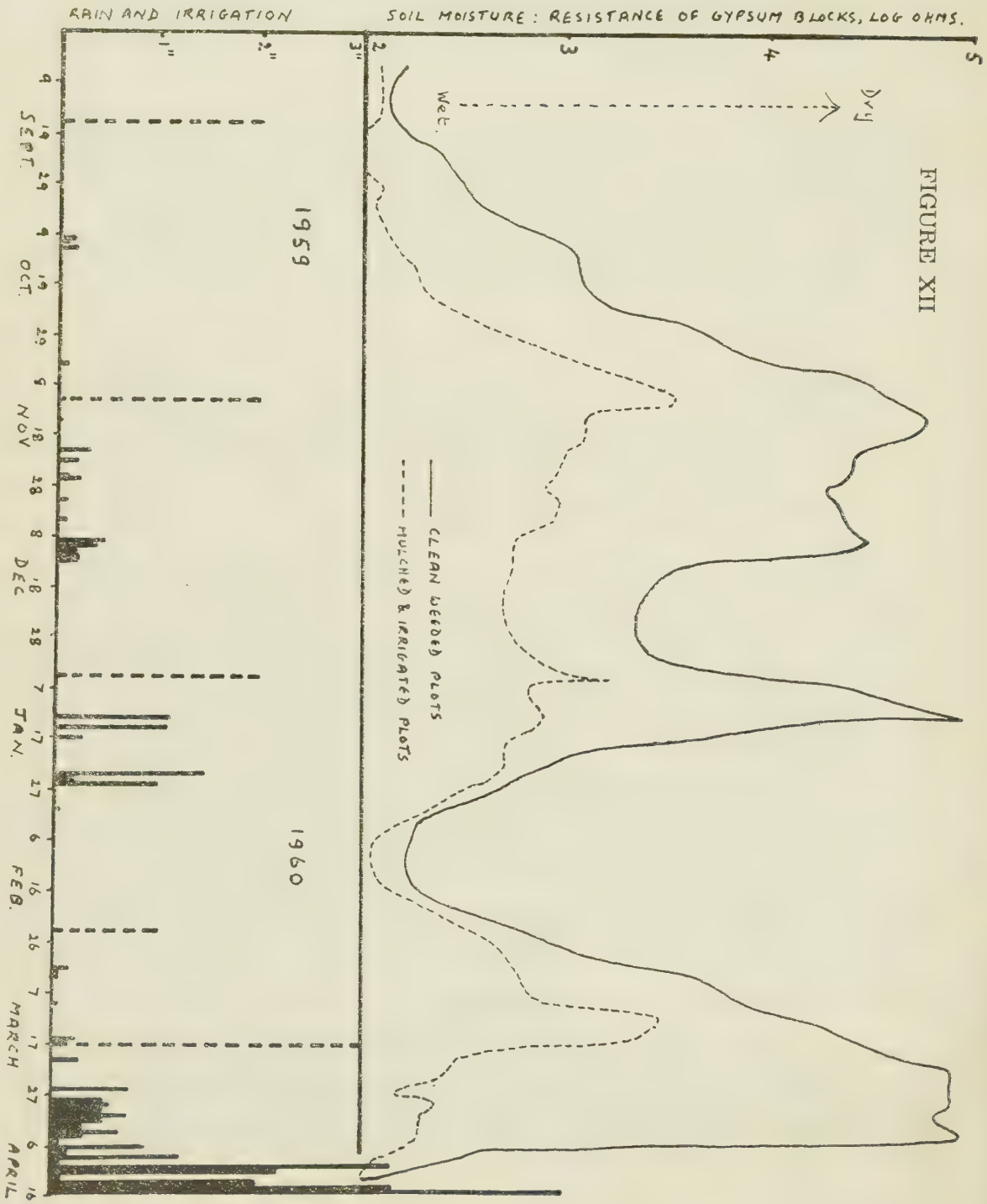


FIGURE XII

Nitrogen was determined by the method of Robinson (15). The remaining elements were determined after digestion of one gram sub-samples with nitric and perchloric acids by a method similar to that described by Bould et al, (16) potassium by direct determination with a flame photometer, calcium and magnesium by the method of Padhye (17), and phosphorus colourimetrically using ammonium vanadate and ammonium molybdate after Snell et al. (18).

Potassium in Table XIV was determined by a new method of the author (20).

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COFFEE LEAF-MINER EPIDEMICS IN RELATION TO THE USE OF PERSISTENT INSECTICIDES

By R. G. TAPLEY, Entomologist

Introduction :

Leaf-miner has become a major pest of coffee during the past decade, causing severe annual defoliation. Epidemics have become more intense and widespread than ever before, and many farmers are now using parathion to keep the pest under control.

The question naturally arises as to whether the use of DDT since 1948, and subsequently dieldrin for the control of Antestia (*Antestiopsis lineaticollis*) and Thrips (*Diarthrothrips coffeae*), is responsible for the epidemics. For this reason it was decided to re-examine the leaf-miner/parasite complex, and to study the effect of DDT and dieldrin on parasite populations. It is known from past experience that neither of these insecticides have much influence on the leaf-miners themselves.

Notley studied the complex relationships between the Leucopteran leaf-miners and their parasites from September, 1938 to November, 1940 during three successive leaf-miner outbreaks which were classed as severe, very mild and mild respectively. His data and conclusions have been published (1), (2). During those years leaf-miner was very much less severe than it has been in recent years (3).

There are two species of Leucopteran leaf-miner pests in coffee on the slopes Mt. Kilimanjaro: —

Leucoptera meyricki, Ghesquière
Leucoptera caffeina, Washbourn.

In Tanganyika *L. meyricki* was known until September, 1958 as *L. coffeella* Guer. The identity was checked by Bradley (4) who found that the East African species was in fact *L. meyricki* and previous records of *L. coffeella* were based on misidentifications.

The position as it was prior to the use of DDT and Dieldrin in Coffee :

The Leaf-miners:

Notley in 1938-1940 stated that '*L. coffeella* (=*L. meyricki*) exists most commonly on unshaded coffee though it is found also on shaded coffee, where its presence may be masked by *L. caffeina* which is often epidemic in such situations' (1). '*L. caffeina* is comparatively rare on unshaded coffee' (2). Prior to 1950 Notley considered *L. meyricki* to be of small importance, but *L. caffeina* caused complete defoliation in outbreaks which, however, tended to be limited in area, although there was a lot of insidious defoliation, particularly in the higher altitude coffee (3).

The Outbreak Pattern:

Notley (1), (2) found that the outbreak pattern was similar for both species of leaf-miner during each of the three seasons. The pattern was as follows: —

(1) At one period of the year, usually during the months of February to July or August, leaf-miner populations were very low. At the end of this period the degree of parasitism of larvae and pupae was also very low.

(2) In June or even as late as August, leaf-miner populations started to

rise, the degree of parasitism remained very low, about 80-90% of the leaf-miners escaping parasitism.

(3) Leaf-miner populations continued to rise slowly and then increased rapidly to reach a peak from October to December. By this time leaf-miner parasite populations had risen considerably, about 70% of the leaf-miners being parasitised.

(4) Leaf-miner populations fell off rapidly, in January and February and the degree of parasitism increased to about 90%.

From Notley's data there seems little doubt that leaf-miner populations from 1938-1940 were dominated by their parasites except during epidemics, but as there was only one severe outbreak during the three seasons under observation, it would appear that parasites effectively held their hosts in check for all but three or four months of the whole period.

An interesting feature of the severe outbreak in 1938 was that a great preponderance of leaf-miner individuals were at the same stage of development at one time.

THE PARASITES:

Notley considered that the following parasites were the most important species: —

(1) *Apanteles bordagei* Giard. was nearly always present and often parasitised up to 30% of the larvae in unshaded coffee, and as high as 60 to 80% in shaded coffee. *A. bordagei* did not parasitise *L. caffeina.*

(2) *Zagrammosoma* (*Atoposoma*) *variegatum* var. *afra* Silv. was extremely important in unshaded coffee where it appeared to dominate *A. bordagei.* It parasitised about 40% of the leaf-miner larvae during epidemics and up to 100% afterwards.

(3) *Parahormius leucopterae* Nixon ('Hormius') was an important parasite emerging from pupae, from 50% to 70% of pupae being attacked during epidemics.

(4) *Pleurotropis coffeicola* Ferr. also emerged from pupae, with records of emergence from up to 50% of the sampled pupae, but it generally appeared to be relatively more numerous when leaf-miner outbreaks were subsiding, or between outbreaks. It was generally more important than *P. leucopterae* under shaded conditions.

(5) *Ageniaspis* sp. under shaded conditions (of no importance in unshaded coffee) was of considerable importance especially in the months when the percentages of other parasites fell to a low level. On the average 3.5 *Ageniaspis* sp. adults emerged from one host. (For this reason all *Ageniaspis* sp. numbers quoted in this paper have been divided by 3.5).

The other parasites including *Achrysocharella ritchiei* Ferr., *Chrysocharis lepelleyi* Ferr., *Elasmus leucopterae* Ferr., *Teleopterus leucopterae* Ferr., *Eulophus borboricus* Giard., *Cirrospilus cinctiventris* Ferr., *Hemiteles sp., Syntomosphyrum* sp. and *Pleurotropis* sp. were described as never being found in sufficient numbers to affect the population appreciably.

The present position :—

THE LEAF-MINERS:

Recent work has shown that *L. meyricki* is now the dominant species of leaf-miner in both shaded and unshaded coffee. *L. caffeina* plays a lesser rôle almost everywhere and the damage it causes is completely overshadowed by that of *L. meyricki.*

On the Coffee Research Station, Lyamungu, for example, where the leaf-miner/parasite complex is being re-examined, of 8,000 moths which emerged

from samples of mined leaves collected in shaded coffee, over 96.5% were *L. meyricki*. In individual blocks of coffee *L. caffeina* accounted for a minimum of 1.3% to a maximum of 17.4% of the total moth emergence.

A survey made on coffee in the Mt. Kilimanjaro areas from September, 1957 to September, 1959 showed that leaf-miner damage is widespread. In the altitude range from 3,500' to 4,750', where the bulk of the coffee crop is produced, a mean maximum of 52% of damaged leaves was recorded at the time defoliation caused by other factors was already severe. At higher elevations leaf-miner damage was somewhat less (5).

THE PRESENT OUTBREAK PATTERN:

One block of coffee of 3¼ acres on the Coffee Research Station, Lyamungu was set aside for the purpose of re-examining the leaf-miner/parasite complex and the outbreak pattern (see Figure XIII). This block had not been sprayed with any insecticide or fungicide, except as described later, since early 1958. Observations commenced in September, 1958. The method of sampling leaf-miner /parasite populations is different from that used by Notley (1) and is one suggested by Dr. B. R. Bartlett of the University of California Citrus Experimental Station, Riverside. Coffee leaves containing active leaf-miner caterpillars (as far as it is possible to tell by superficial examination) are collected at random throughout the block. One hundred of these, after being examined for other insects pests, are placed in an 8 lb. paper bag which is sealed with staples and sticky tape. Six weeks later the bags are opened and the number of each species of leaf-miner moth and parasite counted. Samples are taken every fortnight except for a short period during the year when new miners are very difficult to find, and then one sample per month is taken.

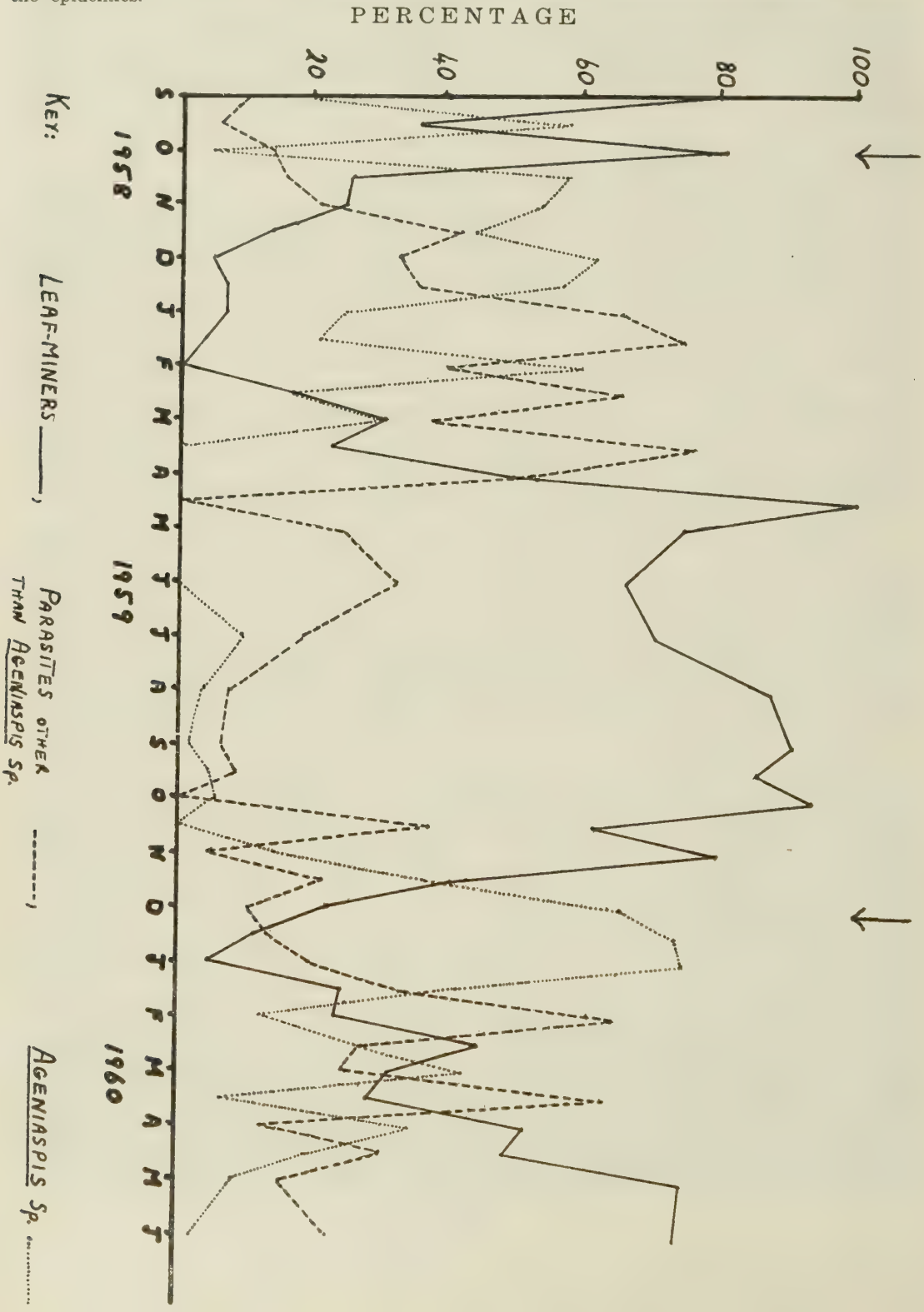
The annual cycle now is basically very similar to the pattern of twenty years ago (1) (2). In 1959 a study of this cycle showed that firstly there is a period beginning in February when leaf-miner populations are extremely low, and when there is a very high level of parasitism. By mid April the parasites have disappeared. Then follows a period of about 6 months when the leaf-miners are largely free of parasites although these recover to some extent in May, June and July and almost disappear again in September and early October. In September leaf-miner populations noticeably increase, slowly at first, until a peak is reached early in December. One month after the climax of the outbreak almost all of the leaf-miners are parasitised, and once again leaf-miner populations decline sharply to a very low level.

One of the differences that is apparent from the position twenty years ago is that the extremes of the degree of parasitism now appear to be very much more marked. Notley (1) in his paper shows that the degree of parasitism in 1938, 1939 and 1940 rarely exceeded 90% and often was very much less, and when parasite populations were relatively low it was rare for less than 10% of the miners to be parasitised. At present it is now usual for the degree of parasitism to range from almost 0% to 100%.

It is also believed that the actual density of leafminers per acre now oscillates between lower and higher extremes. At a certain period of the year, mostly from February to May, it is difficult to find enough active mines to form a 100 leaf sample, whereas Notley was able to continue collecting adequate numbers of larvae and pupae throughout the year. His records of the number of eggs per tree also indicate that each tree always supported at least a small population of miners. This is certainly not the case today. At the other extreme, at the peak of the outbreaks, the number of eggs placed on many leaves is such that the resultant larvae cannot be supported for the want of food. No actual figures are available, but observation shows that oviposition is common on old mines and on leaves about to fall, resulting in high larval mortality. Were it not for this factor

Figure XIII.—Showing the relative number of leaf-miners and parasites (expressed as percentages of the total number of insects in each sample) over the sampling period, from September, 1958 to June, 1960.

Parasites other than *Ageniaspis* sp. include *A. bordagei, Z. variegatum* var *afra, P. leucopterae, E. leucopterae P. coffeicola* and *A. ritchiei.* The arrows indicate the peaks of the epidemics.



it seems likely that the parasites would be even slower in bringing the epidemics under control.

THE PARASITES:

The parasite complex is now very different from 20 years ago. *Ageniaspis* sp. which at that period played a very small part in bringing epidemics under control and was only present in collections if other parasites were absent, now appears to play the major róle in checking epidemics. During the 1958 epidemic *Ageniaspis* sp. parasitised up to 62% of the miners, and in the 1959 epidemic up to 75%. Moreover, from mid-March to mid-November *Ageniaspis* sp. was either present in very small numbers or completely absent. This is in contrast to the period 1938 to 1940 when *Ageniaspis* was relatively more numerous during these months than at any other time of the year.

Parahormius leucopterae which used to be so important is now absent from almost all collections and comprises no more than 0.4% of the total. *A. bordagei* is also comparatively rare and comprises 6% of the total parasite collection, and appears mostly after the climax of the outbreak. *Z. variegatum* var *afra* appears sporadically and amounts to only 0.8% of the total collections. *Achrysocharella ritchiei* appears to be more numerous now than previously and comprises 13% of collections. *Elasmus leucopterae* was found in very small numbers. The status of *Pleurotropis coffeicola* remains unchanged, but its value is doubtful since it is very largely a secondary parasite, that is it destroys many of the primary parasites.

While no other one parasite appears in important numbers the total effect of *A. bordagei, Z. variegatum, P. leucopterae, A. ritchiei E. leucopterae* and *P. coffeicola* is considerable and is shown in Figure XIII. The other parasites collectively become important after *Ageniaspis* reaches its peak, and there appears to be a struggle between *Ageniaspis* and the other parasites for the dominant position. *Ageniaspis* declines first and the other parasites colectively become more important during the period from approximately February to late September, when leaf-miner populations are low.

THE POSITION IN OTHER PLOTS ON THE COFFEE RESEARCH STATION, LYAMUNGU:

Regular observations were made in five other plots on the Coffee Research Station. The position as described above is very similar in each of the plots and does not warrant separate descriptions.

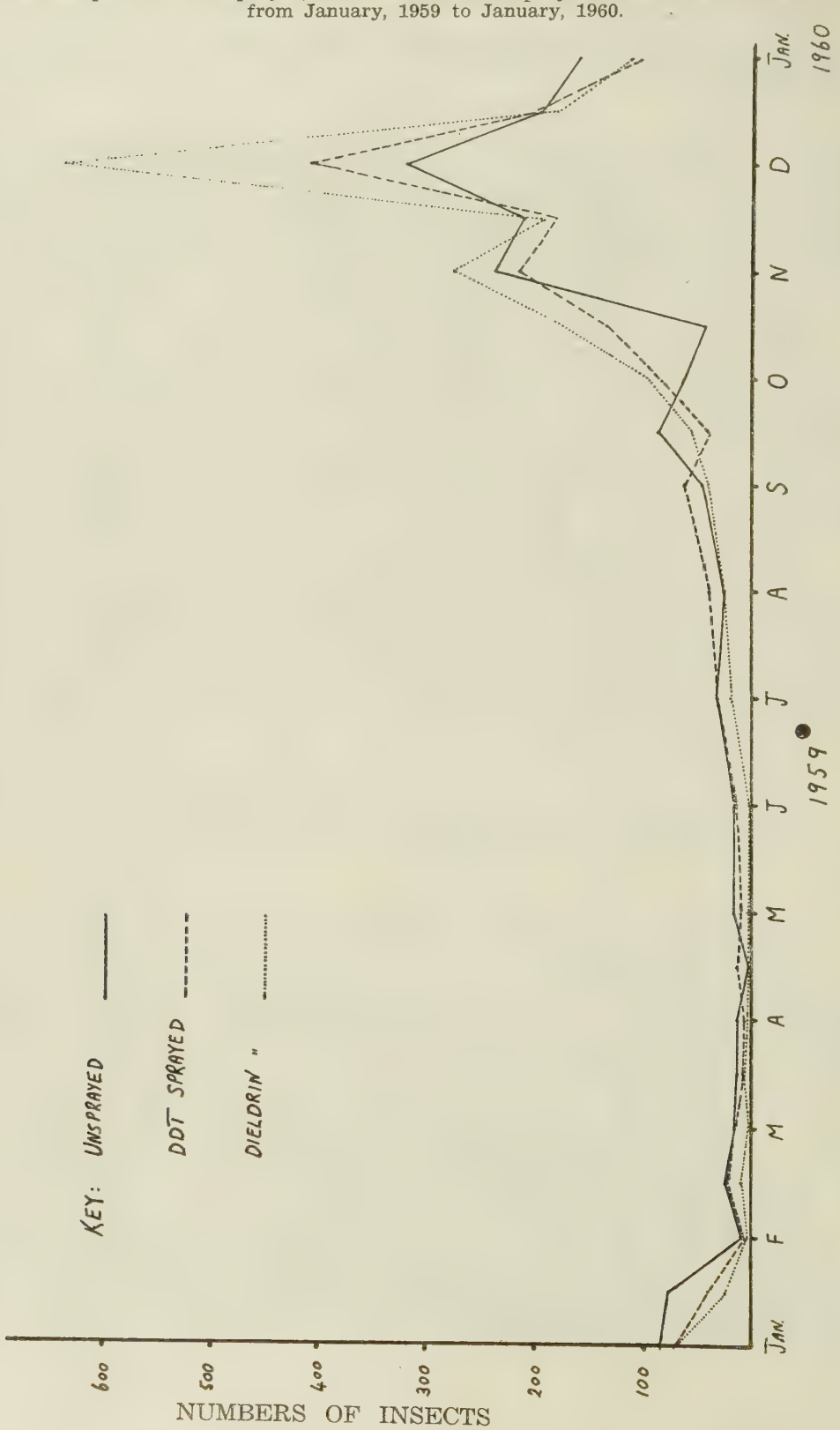
The effect of DDT and Dieldrin on Leaf-Miner Populations and their Parasites

Within the unsprayed 3¼ acres block of coffee on the Coffee Research Station, Lyamungu, two plots of 11 x 11 trees (.22 acre) each were sprayed respectively with DDT and dieldrin at usual field rates for the control of Antestia and thrips. From the central 25 trees of each plot leaf samples were taken at the same time as samples were taken from the rest of the plot, and in the same way. The sprayed trees outside the central portion of the plots served as guard rows to slow down the invasion of parasites from the unsprayed trees. At the time of the year when new mines were difficult to find, however, it was necessary to take samples of mined leaves from the the guard row as well as the plot.

The samples of mined leaves were placed in bags as already described and the emergent moths and parasites counted. The results are illustrated in Figures XIV, XV and XVI and Table XV.

During the off-season, that is from February to August or September, dieldrin appeared to depress the parasite population in mid-February and March; and both insecticides appeared to depress the parasite populations in June (Figure XVI). However, neither insecticide at any time influenced the number of insects emerging from the leaves (Figure XIV).

Figure XIV.—Showing the total numbers of leaf-miners and parasites emerging from 100 mined-leaf samples from unsprayed, DDT and dieldrin sprayed trees. The results are shown from January, 1959 to January, 1960.



During the epidemic important differences could be detected between the sprayed and unsprayed trees. Figure XIV illustrates the total number of leaf-miner moths and parasites emerging from the 100 mined-leaf samples collected fortnightly during this period. Figure XV shows the number of leaf-miner moths only contained in the same samples during the epidemic. From these figures it can be seen that the emergence peak for the total number of leaf-miners plus parasites, which occurred in early December, was the same in all three treatments. However, more insects emerged from both the dieldrin and DDT treated leaves than from the unsprayed leaves, the dieldrin treated leaves yielding almost twice as many insects.

An examination of the actual numbers of leaf-miner moths which emerged from the samples (Figure XV) shows a rather different picture. There was a peak emergence in all treatments early in November, and thereafter the number of moths from the unsprayed trees declined. From both DDT and dieldrin sprayed trees a second and greater peak emergence of moths occurred in early December. Thereafter the decline of moth populations in early January was very similar in each case.

Throughout the trial it can be seen (Figure XVI) that the parasite populations as a whole appear to recover in the sprayed plots within 6 weeks or 2 months after application. This is probably due to re-invasions of parasites from the unsprayed trees, but it may well be the case that in larger sprayed plots (e.g. whole farms or districts) the recovery of parasite populations may be appreciably slower.

Figure XV.—Showing the number of leaf-miner moths emerging from mined-leaf samples taken from unsprayed trees, and trees sprayed with DDT and dieldrin. The arrows indicate the dates of spraying. Data is shown from August, 1959 to January, 1960.

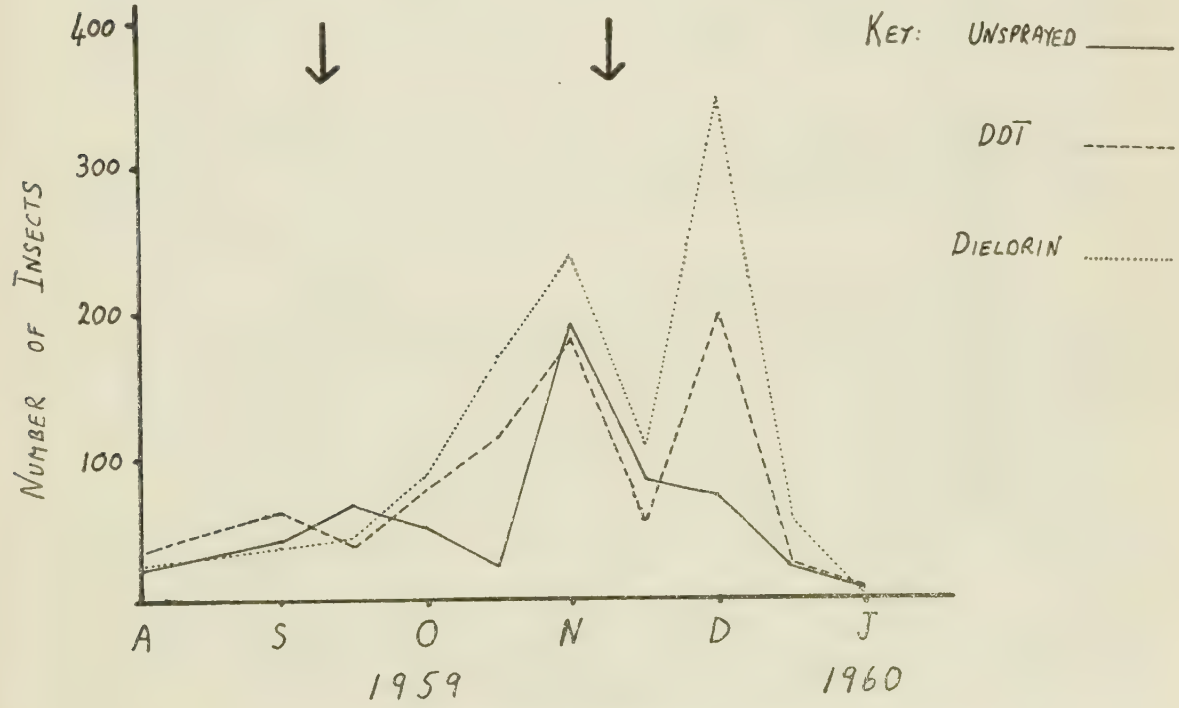
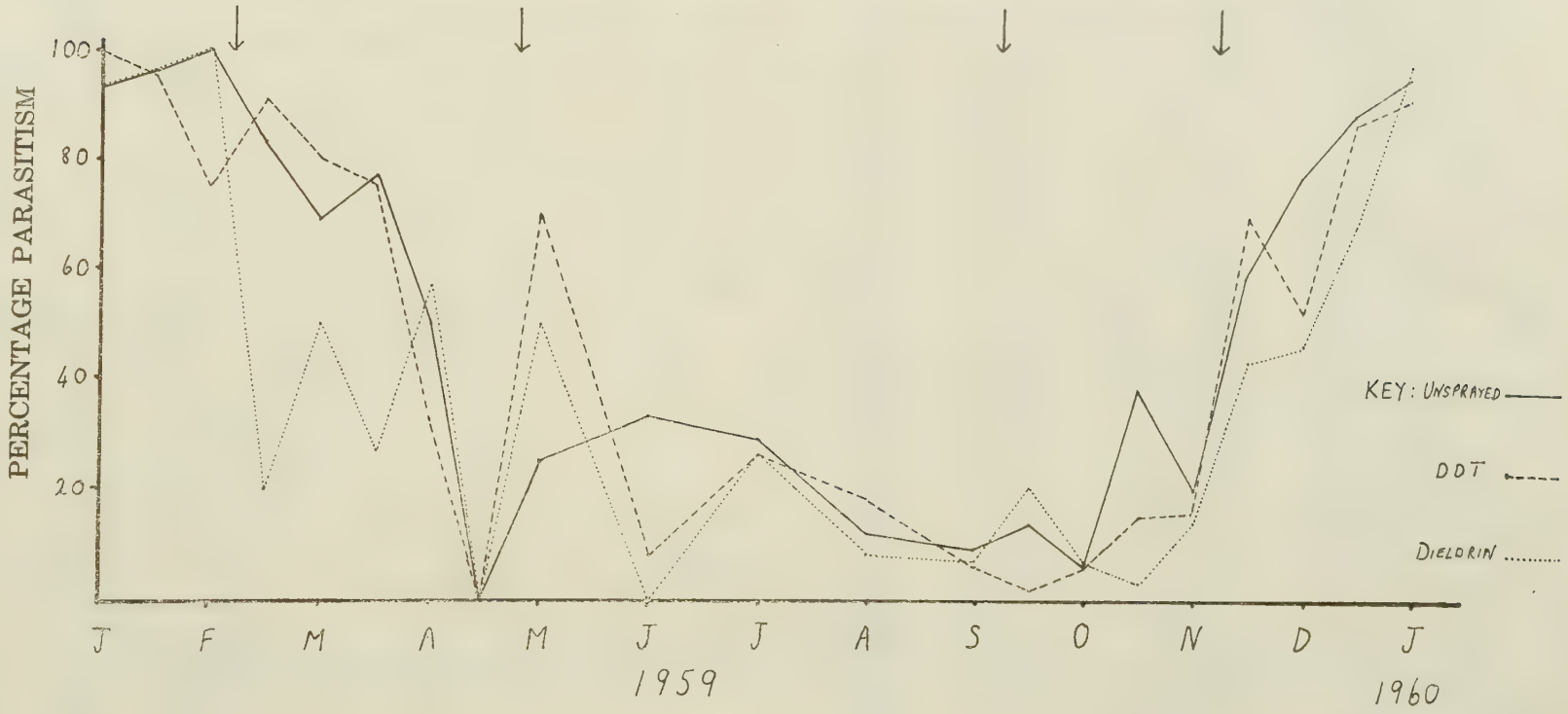


Figure XVI.—Showing the degree of parasitism in leaf-miner populations (expressed as percentages) in unsprayed, dieldrin and DDT sprayed trees from January, 1959 to January, 1960. The arrows indicate the times of application of the insecticides.



THE PARASITE POPULATIONS DURING THE EPIDEMIC:

The degree of leaf-miner parasitism in the three treatments is illustrated in Figure XVI. In August and early September the parasites were scarce in all treatments including the unsprayed trees. The first application of insecticide was made soon after the first September sample was taken. Early in October parasites were again scarce in all treatments, but in mid-October there was a marked difference between the treatments. Almost 40% of the miners in the unsprayed trees were parasitised compared with 15% in the DDT and 3% in the dieldrin plots. Early in November with the first peak emergence of leaf-miner moths all treatments were parasitised to a similar degree, that is, between 15% and 20%. At this point the second dose of insecticide was applied and the effect of this is shown clearly in Figure XV. The second and higher peak emergence of moths appeared in both of the insecticide treated plots early in December. The generation of leaf-miner caterpillars arising from the peak emergence of moths in early November was largely parasitised in the unsprayed trees, to the extent of 77% of the leaf-miners. In both the DDT and dieldrin sprayed trees parasitism was reduced to 52% and 46% respectively. Apparently, the insecticides had destroyed a high proportion of the parasites in the sprayed plots, thus allowing a second and higher peak of moth emergence in early December. By early January the degree of parasitism rose to above 90% in all plots, the effects of the insecticides apparently having disappeared.

An analysis of the proportion of each species of parasite is shown in Table XV. The data are not suitable for statistical analysis, but they do show that *Ageniaspis* sp. is the dominant parasite in each treatment, and that *A. ritchiei* is the next in order of importance.

The data in Table XV also suggest that of the two insecticides DDT does comparatively little harm to the parasites other than *Ageniaspis* sp., *Achrysocharella ritchiei* appears to be resistant to, or tolerant of DDT and can compete favourably with *Ageniaspis* sp. for the available hosts. Dieldrin on the other hand appears to depress the other parasites in favour of *Ageniaspis* sp. which becomes even more important in bringing leaf-miner under control. *Achrysocharella ritchiei* appear to be not so resistant to, or tolerant of, dieldrin.

DISCUSSION:

It is interesting to speculate on the cause(s) of the changes in the leaf-miner/parasite complex which has taken place over the last two decades, and whether this change has led to the more extensive and severe epidemics that have occurred in recent years. Furthermore, why should the status of the two species of leaf-miners have changed so strikingly?

CAUSE(S) OF THE CHANGES IN THE LEAF-MINER/PARASITE COMPLEX:

It has been shown here that the use DDT and dieldrin insecticides can, by reducing parasite populations generally, intensify an outbreak and prolong an epidemic. These insecticides also appear to affect the populations of each species of parasite in different ways. DDT, for example, tends to favour the survival of *A. ritchiei* and the dieldrin treatment favours *Ageniaspis* sp. Both of these species which were considered to be unimportant two decades ago, are now the dominant species. The status of *P. coffeicola* which alone of the once important species remains more or less unchanged, was also unaffected by DDT and certainly not entirely suppressed by dieldrin. From this it can reasonably be concluded that the change of status of most of the parasites may well be attributed to the use of DDT, which was widely used up to 1958, and dieldrin, which has been used more extensively since that time as coffee sprays for insect control.

It would be interesting to see if the leaf-miner parasite complex as described by Notley still existed in coffee which had remained unsprayed with the newer, persistent insecticides and only treated with those older insecticides

TABLE XV

Showing the percentage of each species of parasite in the total parasite collections from Unsprayed, DDT and Dieldrin sprayed plots during the period from August, 1959 to February, 1960

Treatment	*Apanteles bordagei*	*Zagrammosoma (Atoposoma) variegatum* var afra	*Parahormius leucopterae*	*Pleurotropis coffeicola*	*Ageniaspis* sp.	*Achrysocharella ritchiei*	*Elasmus leucopterae*	*No. of parasites in Collection*
Unsprayed trees	6.1	0.8	0.4	5.0	73.4	13.2	0.7	897
DDT sprayed trees	8.0	2.3	0.6	4.2	61.4	22.1	0.9	722
Dieldrin sprayed trees	1.9	0.9	0.7	3.2	85.7	7.2	0.1	770

as used two decades ago. Unfortunately, no such coffee is known to exist on Kilimanjaro, and the best that can be done is to set aside an area of coffee, leave it unsprayed for several years and see if the old complex is restored. If this is the case, and if the new complex remains the same in sprayed plots, then the case against the use of DDT and dieldrin in coffee would be very convincing.

THE CHANGE IN DOMINANCE OF THE LEAF-MINER SPECIES:

There has been no indication in the data obtained of the reason why *L. meyricki* should now be the more important of the two species. However, one explanation may be that of the four parasites that Notley (2) described as being important in controlling *L. caffeina,* namely *Pleurotropis coffeicola, Ageniaspis* sp., *Parahormius leucopterae* and *Eulophus borboricus,* the first two species are still relatively abundant in spite of (or because of) insecticide treatment. It may be the case that both of these species have a preference for *L. caffeina* and consequently have kept it well under control.

THE CAUSE OF LEAF-MINER EPIDEMICS:

While there is evidence to suggest that the use of DDT and dieldrin can intensify and prolong an epidemic there is no evidence to suppose that they are the prime cause of them. Insecticides in February and May in this study did not increase the number of insects emerging from the leaf-samples (Figure XIV) and the rate of increase in the number of insects emerging from the leaf-samples of sprayed and unsprayed trees from July to September, the beginning of the epidemic, was very similar. Furthermore, the epidemics of 1938, 1939 and 1940 reported by Notley occurred long before DDT and dieldrin had been marketed.

The chain of events which eventually leads to an epidemic appearing is not understood, but it may well be associated with the annual oscillation of the degree of parasitism from almost 0 to 100%. Apparently the cycle of events is something like this: Towards the end of the epidemic almost 100% of the leaf-miner caterpillars and pupae are parasitised and the host population is consequently drastically reduced in the following generation. As a result the parasite populations themselves must follow suit because of the scarcity of food and are thereby reduced drastically. This factor alone, the rapidly diminishing populations of hosts and parasites, would not necessarily account for the almost complete disappearance of the parasite populations unless the leaf-miner was able to survive at a relatively lower population density than the parasites. This may well be the case since there is only one species of the host (*L. caffeina* can be ignored at present because of its paucity of numbers), but there are several species of parasite competing for that one host. Therefore, the population density of any one species of parasite must be relatively lower than the leaf-miner population density. It is interesting to note that *P. coffeicola* is usually the last parasite to disappear, probably because it can parasitise some of the other parasites as well as the leaf-miner.

On the other hand, if epidemics were caused by a simple oscillation from a low to a high degree of parasitism then presumably an epidemic could occur at any time of the year. In fact, more than one epidemic in any one year could be reasonably expected, but this is not the case. A recent 2 year survey on Mount Kilimanjaro covering a wide range of conditions (5) showed that leaf-miner epidemics always occur at the same season of the year, that is from September to February, and there is never more than one epidemic in any year. This would suggest that, in some way, an epidemic is linked with climate.

The nature of this link with climate is not understood, but there are several possibilities:

Firstly, certain climatic conditions may affect adversely leaf-miner

populations during one season of the year. For example, it is belived that during the heavy rains of April and May some mines become damaged and flooded. A second possibility is that the weather may affect entomogenous fungi or other diseases of leaf-miners, particularly during those months of the year when very few leaf-miners emerge from the samples and the degree of parasitism is low (see Figures XIV and XVI). Notley (2) found a high mortality amongst the first instar larvae of *L. caffeina* at certain times of the year, the cause of which was unknown, and it was observed during the 1959 epidemics at Lyamungu that there was an appreciable number of deaths of leaf-miner larvae which could not be attributed to either parasites, insecticides or physical damage. A third possibility is that a seasonal host—resistance may also slowdown or prevent development of the larvae in their mines. For example, dead leaf-miner larvae have been found embedded between callus cells proliferating from the spongy mesophyll as described by Hering (6) of other species of leaf-miner, but it has not been determined whether the formation of callus tissue causes or follows the death of the insect.

Whatever the link between epidemics and climate may be it would be interesting to understand the mechanism, and it may then be possible to find a way of preventing epidemics from arising.

SUMMARY:

(1) In recent years leaf-miner epidemics have become more severe, and more extensive than during the years before 1950.

(2) The leaf-miner/parasite complex, which was first studied on the Coffee Research Station, Lyamungu, from 1938 to 1940, has been re-examined.

(3) The following conclusions have been drawn: —

(i) The outbreak pattern now is very similar to that described previously.

(ii) The status of the leaf-miners has changed. Hitherto, *Leucoptera caffeina* was considered to be of economic importance and *L. meyricki* of no great importance. Today, *L. meyricki* is the dominant leaf-miner and causes extensive defoliation in both shaded and unshaded coffee. *L. caffeina* now plays a secondary róle and is comparatively unimportant.

(iii) The status of the parasites has also changed.

Apanteles bordagei, Zagrammosoma (*Atoposoma*) *variegatum* var *afra* and *Parahormius leucopterae,* which were described as being the key parasites in keeping leaf-miners in check now play a very small part in controlling epidemics. *P. leucopterae* has almost disappeared. The status of *Pleurotropis coffeicola* is apparently unchanged. *Ageniaspis* sp. which, under shaded conditions was only of importance during the months when the number of other parasites fell to a low level and in unshaded coffee of no importance at all, is now the dominant parasite in all collections. It almost disappears during the months when leaf-miner populations are low. *Achrysocharella ritchiei,* which used to be of little importance now appears in most collections, although it cannot be described as being of prime importance.

(iv) Both dieldrin and DDT sprayed during an epidemic prolonged the epidemic and intensified the attack. The number of insects (both leaf-miner moths and parasites) emerging from mined leaves at the peak of the outbreak was almost double in the dieldrin sprayed trees compared with the number emerging from unsprayed trees.

(v) Dieldrin is shown to increase the ratio of *Ageniaspis* sp. to the other parasites. DDT apparently has had the effect of increasing the ratio of *A. ritchei* although *Ageniapis* sp. was still the dominant parasite.

ACKNOWLEDGEMENTS:

I am indebted to Dr. Blair R. Bartlett of the University of California Citrus Experimental Station, with whom the problem of leaf-miner epidemics was discussed during his visit to the Station in August 1958, and who suggested the programme of work described in this paper.

Mr. David Marenga was responsible for most of the sampling and insect sorting.

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THE EFFECT OF CAPTAN AND COPPER SPRAYS ON LEAF RUST AND LEAF FALL OF COFFEE

By D. A. BURDEKIN, Plant Pathologist

Introduction:

Recent experiments in Kenya have indicated that Captan may give good control of Coffee Leaf Rust *Hemileia vastatrix* and generally improve the growth of coffee trees. Early experiments in Tanganyika did not yield such good results. This experiment was designed to investigate the apparent anomaly by applying several different Captan treatments and comparing them with the present Copper spray recommendations.

Site — Tengeru, deep level volcanic soil.
Date planted — 1954.
Spacing — 9 ft. x 9 ft.
Shade — Moderate shade.
Pruning System — Single Stem.
Trial Commenced — 1960.
Previous Treatments — Nil.

Layout:

6 x 6 Latin Square; single tree plots, each surrounded by a square of untreated trees.

Treatments:

A Control — no fungicide.

B Copper — 5 lbs. of a 50% Copper formulation per 100 gallons/acre applied every two months.

C Captan — 4½ lbs. per 100 gallons/acre. applied 4 times February-March.

D Captan — 4½ lbs. per 160 gallons/acre applied 4 times February-March.

E Captan — 4½ lbs. per 100 gallons/acre applied every two months.

F Captan — 4½ lbs. per 160 gallons/acre applied every two months.

Methods of Application:

Treatments B to F were all applied with a stirrup pump sprayer and measured bucket. Approximately 900 c.c. were applied to each tree in treatments B, C and E and approximately 1400 c.c. in Treatments D and F.

Results:

No yield Figures are yet available and no marked response is expected in the first year of the trial.

The number of leaves present on the distal ten nodes of three primaries per tree was recorded every fortnight to give an indication of the percentage leaf retention.

The percentage of these leaves infected with Coffee Leaf Rust was also recorded to give an indication of infection.

Table XVI shows the totals and means over an eight month period from January to September, 1960 of :—

(a) The percentage of leaves retained per primary.

(b) The percentage of leaves infected with Coffee Leaf Rust.

TABLE XVI

Treatments	Totals of percentage leaves retained per primary	Means	Totals of percentage infection with Leaf Rust	Means
A (Control)	873.3	46.0	714.0	37.6
B (Copper)	1002.7	52.8***	757.8	39.9*
C (Captan)	987.1	52.0***	593.3	31.2***
D (Captan)	1023.7	53.6***	443.3	23.3***
E (Captan)	892.8	47.0	592.5	31.2***
F (Captan)	923.5	48.6	650.0	34.3*
	Least Significant Differences		Least Significant Differences	
	2.8* 3.8** 5.0***		2.9* 3.8** 5.0***	

NOTES : * = Statistically Significant at the 5% level
** = Statistically Significant at the 1% level
*** = Statistically Significant at the .1% level

It will be seen that the treatments which have given the best retention of leaves are B, C and D. These are the Copper Spray Treatment, and the two Captan Spray Treatments applied in February and March. The treatments which give the best control of Coffee Leaf Rust are C, D and E. These are all Captan Spray Treatments, two applied in February and March, the third applied every two months. In this experiment Copper has not given any control of Coffee Leaf Rust but has given good leaf retention. Captan Treatment D has given the best leaf rust control.

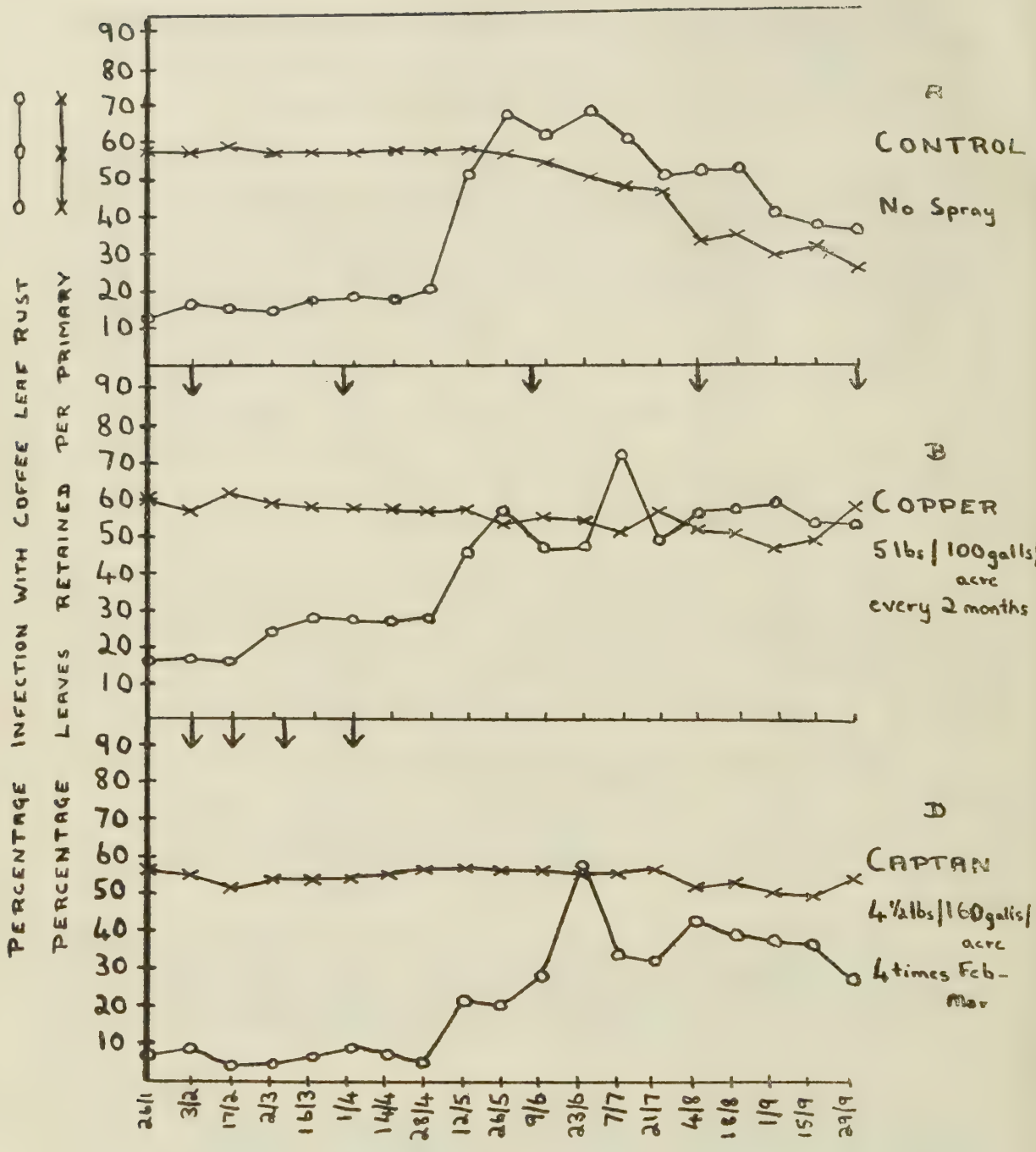
Figure XVII shows the two records expressed graphically for the unsprayed, copper sprayed and the best Captan sprayed treatments.

The graph for Control shows a slow build up of Leaf Rust from January to April followed by a rapid rise in May. From the middle of June there is a gradual decline. The graph showing percentage leaf retained falls at a gradually increasing rate.

The graph for Copper shows a more staggered build up of Leaf Rust and there is no definite decline except from one high figure in July. It is of interest to note that in at least two cases (March and May sprays) there is a build up of Leaf Rust between 5 and 7 weeks after spraying. The significance of this will be discussed later. The decline shown in the leaf retention graph is halted three times and the final figure for percentage leaf retained is high.

The graph for Captan is similar in all four treatments. The slow build up from January to April of Leaf Rust seen in the unsprayed control is halted and the rapid rise in May is more gradual. The decline from the middle of June is more rapid. Treatments C and D show a remarkable constancy in the percentage of leaves retained until mid July when leaf fall commenced. Treatments E and F show similar leaf retention graphs to control.

FIGURE XVII


PERCENTAGE INFECTION WITH COFFEE LEAF RUST
PERCENTAGE LEAVES RETAINED PER PRIMARY
A
CONTROL
No Spray
B
COPPER
5 lbs / 100 gallis / acre
every 2 months
D
CAPTAN
4½ lbs / 160 gallis / acre
4 times Feb-Mar
90
80
70
60
50
40
30
20
10
26/1
3/2
17/2
2/3
16/3
1/4
14/4
28/4
12/5
26/5
9/6
23/6
7/7
21/7
4/8
18/8
1/9
15/9
29/9
↓ Spray Applications

DISCUSSION

Copper Treatment:

The records on this treatment seem somewhat paradoxical at first with high levels of both infection and leaf retention. This treatment has certainly retained significantly more leaves per primary than control. This has meant that more leaves were available for infection and hence the high incidence of Leaf Rust.

A further interesting observation made in the Results section concerned the increase in infection 5—7 weeks after spraying. Laboratory experiments carried out at the time of these spray applications showed that it took approximately 5 weeks from the time of initial infection until the appearance of a sporulating pustule. It thus appears that the heavy rain this year during the long rains may have removed the protecting layer of fungicide from the leaves.

Captan Treatments:

The object of applying Captan four times in February and March was to reduce the level of infection to a minimum prior to the onset of the long rains. Captan applied at 4½ lbs. in both 100 and 160 gallons to the acre succeeded in this aim. Captan at 4½ lbs. in 160 gallons to the acre (Treatment D) was more successful in retaining leaves on the tree (see Table 1).

Captan applied every two months (Treatments E and F) did not effect an increased leaf retention and only Treatment E showed an appreciable control of Leaf Rust.

CONCLUSIONS

1. The best rate to apply Captan on the basis of these results is 4½ lbs. in 160 gallons per acre four times during February and March.
2. The Copper fungicide applications at present recommended gave good leaf retention.
3. The Copper fungicide did not give good control of Coffee Leaf Rust probably due to the heavy rains this year.
4. Captan at the rate and timings mentioned in paragraph 1 was superior to Copper for leaf rust control.
5. This work continues.
6. These results are not sufficient to issue a recommendation on Captan Spraying.

My thanks are due to Dr. F. J. Nutman, Coffee Berry Disease Research Unit, Kenya, for suggesting this experiment; Mr. R. G. Tapley for suggesting a recording technique; Shell Chemicals for supplying the Captan and Messrs. Wilbald Marikani and Paul Mtimili for carrying out the recording.

SURVEY OF RACES OF COFFEE LEAF RUST IN NORTHERN TANGANYIKA

By D. A. BURDEKIN, Plant Pathologist

Coffee Leaf Rust is caused by the fungus *Hemileia vastatrix* Berk. and Br. This fungus, like *Pucinia graminis* Pers. causing Black Stem Rust of Wheat, exists in a number of races. Eleven races have so far been identified (number I—XI) throughout the coffee growing areas of the world.[1,2] Only three (a fourth is as yet unconfirmed) of these have been found in East Africa.[3]

A survey of the races of *H. vastatrix* present in the Northern part of Tanganyika has been carried out at the following localities :—

NORTHERN PROVINCE :—

Tengeru	Uru Rau	Monduli	Mbosho
Lyamungu	Kiru Valley		

TANGA PROVINCE :—

Lushoto	Pare	Usangi	Mshewa

EASTERN PROVINCE :—

Uluguru Mtns. (Kibuko)

In order to differentiate one race from another a series of differential selections is used. In the present survey differentials are used to identify Races I, II and III.

SL 6 (Kent Type) — Susceptible to Race I.

SL 34 (Bourbon Type) — Susceptible to Race I and II.

VC 496 (Geisha) — Susceptible to Race III (and also Race X which attacks non Arabica coffee).

TECHNIQUES :

Uninfected leaves from the differential selections are detached from the stem at their point of attachment. The leaves are washed in water and thoroughly dried. They are then placed on wet filter paper in Petri Dishes with their under-surface uppermost. The petioles are wrapped in a small wad of wet cotton wool to ensure a continuous supply of water to the leaf.

Inoculation:

Spores from infected leaves are lightly scraped off with a scalpel onto the leaves in the petri dishes and are then sprayed with distilled water. Three leaves of each differential selection are taken for each test.

The first signs of infection show after 3—4 weeks when light yellow spots appear, to be followed after 5—7 weeks by the production of spores. The number of spots or pustules is recorded twice, after 4 weeks and after 6 weeks.

Results:

An example of a recording from the actual results is given below :—
Location : Monduli
Selection : Bourbon
Date started : 29th April, 1960
1st Recording : 26th May, 1960

Differential Selection	SL 6	SL 34	VC 496
Leaf 1	nil	nil	nil
Leaf 2	nil	7 spots	nil
Leaf 3	nil	1 spot	nil

2nd Recording : 10th June, 1960

Leaf 1	nil	1 spot	nil
Leaf 2	nil	20 spots	nil
Leaf 3	nil	10 spots	nil

Race II present.

The following is a table of the results obtained :—

		Selection	Race
Northern Province :			
	Tengeru	Not known	II
	Monduli	Bourbon	II
	Lyamungu	Kent	I
	Lyamungu	Bourbon	II
	Lyamungu	Geisha Hybrid (unconfirmed)	III
	Uru Rau	Not known	II
	Mbosho	Kent	I
	Mbosho	Bourbon	II
	Kiru Valley	Kent	I
	Kiru Valley	Bourbon	II
Tanga Province :			
	Lushoto	Not known	II
	Usangi	Not known	II
	Pare	Not known	I
	Mshewa	Kent	I
Eastern Province :			
	Uluguru Mtns. (Kibuko) ...	Bourbon	II

CONCLUSIONS:

1. Races I and II seem widespread in the Northern part of Tanganyika.
2. If Race III is confirmed at Lyamungu this will be the first record in East Africa of this race.

I am indebted to Mr. R. Sawaki, Mr. A. R. Kabeza and Mr. L. A. Shoo for carrying out the laboratory work and recording.

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THE COMMERCIAL CROP AT THE COFFEE RESEARCH STATION

By L. M. FERNIE—Horticulturist

For the duration of any particular field experiment at Lyamungu, cherry yields are recorded in the field and thereafter the cherry is bulked for processing, except for plot samples and seed which are both treated separately. This bulk, together with any non-experimental *arabica* coffee, comprises the commercial crop which is processed, cured, and sold as plantation coffee.

The crop results for fourteen years are summarized in Table XVII, which is self-explanatory. It must be emphasized, however, that the best coffee has been taken as seed each year and this must have inevitably lowered the grading and classification. It should also be understood that certain treatments, now known to be harmful, were often continued for the sake of a particular experiment, and this has naturally lowered the overall yield still further. These are conditions which would not be experienced on a commercial estate.

Yield:

It should be noted from the table that the highest overall yield in any one year was 13.25 cwt./acre clean coffee and the mean of the fourteen years was 8.16 cwt./acre. This may be considered low, but it is generally explained by the reason given above, and the results from individual experiments published in the annual reports give a true indication of potentialities. When 4-year periods are averaged to give running means, the more violent seasonal fluctuations are removed and a truer indication of average yields is shown.

Tonnage:

The Lyamungu factory was only designed to cope with a 30-ton crop. Drying in particular, has suffered from this disadvantage, and crops of two and three times this amount have been handled in a number of years.

Grading:

Over 80% of the graded crop was placed in the top three grades for five years out of the fourteen. Four of these years were during the five-year period 1948-52, which covered a tonnage range from 18.09 tons to 77.37 tons in a year, a yield range from 2.95 cwt./acre to 13.16 cwt./acre clean coffee, and a rainfall range (November—October) from 38.5 inches to 65.42 inches per season.

Classification:

Over 80% of the graded crop was classified in the first four classes in three out of the fourteen years, and this was during the four-year period 1948-1951. The only time that class 1 has been achieved was in three successive years 1948-1950. The percentages in this class were 11.7, 7.4, and 33.4 respectively.

Correlation of grades and classes:

It can be seen in Figure XVIII that there is a close affinity between the percentage of crop in the first three commercial grades AA, A, and PB and the percentage in the first four liquoring classes. In other words, when there is a high percentage of bold beans it can be expected that the liquoring quality will also be good, provided of course that the methods of processing are satisfactory.

There is a highly significant positive correlation ($p=0.01\%$) between the grades and classes in this comparison ($r= +0.835$).

Summary:

An analysis of the graded commercial crop produced at the Coffee Research Station over the past fourteen years shows a close affinity between the percentage crop in the first three grades and the percentage in the first four classes.

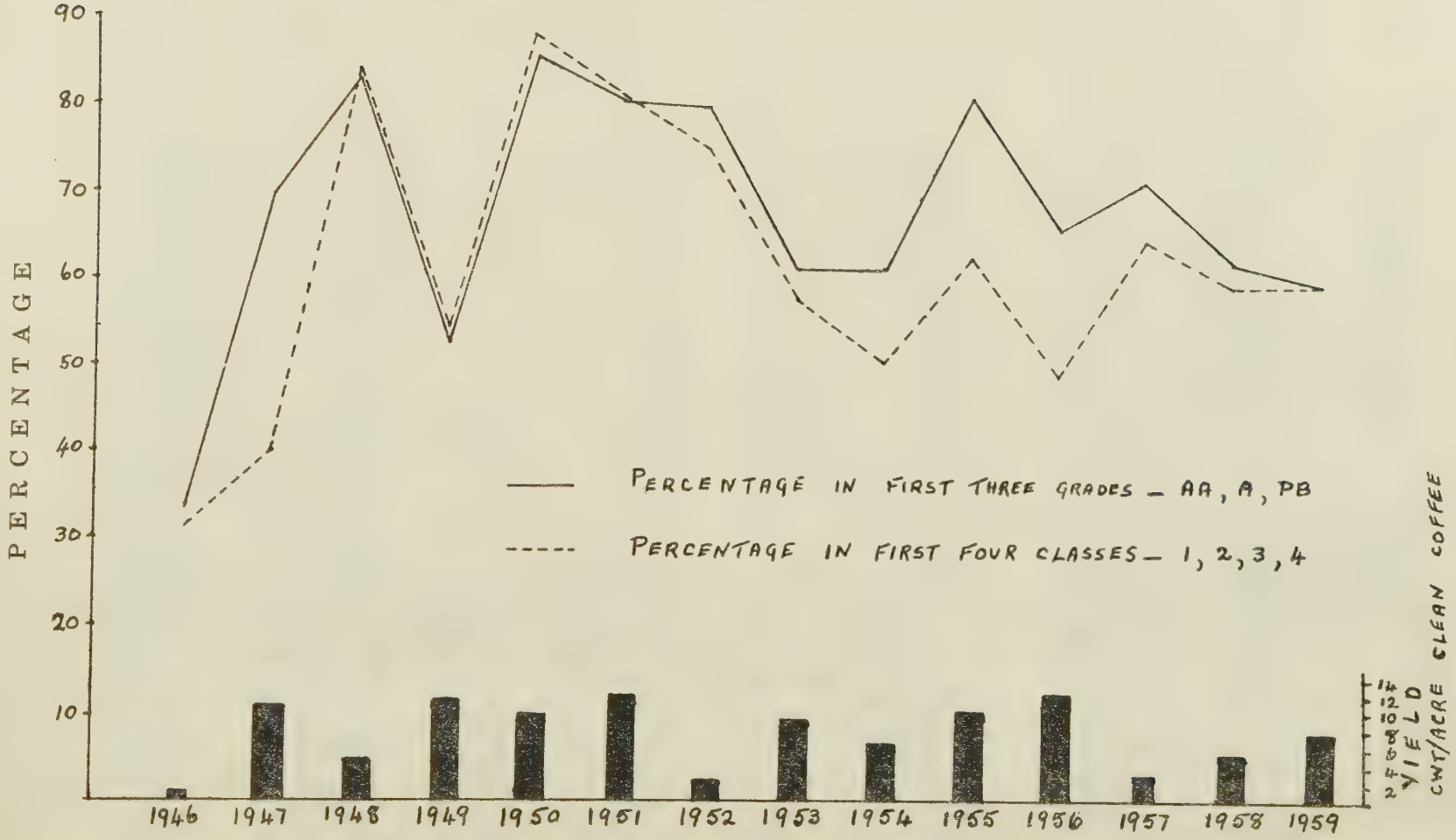
TABLE XVII

Crop results expressed in terms of clean coffee for 14 years 1946-1959

Years	*Total tonnage graded*	*% in first 3 grades*	*% in first 4 classes*	*Total tonnage*	*Acreage bearing*	*Yield cwt./acre*	*Running means*	
							4-year periods	*Yield cwt./acre*
1946/47	3.52	33.9	31.7	4.44	69.46	1.28	—	—
1947/48	41.93	69.8	40.2	42.74	79.04	10.81	—	—
1948/49	20.83	83.6	84.6	21.51	82.28	5.23	—	—
1949/50	47.33	52.5	53.8	50.90	83.78	12.15	1946-49	7.37
1950/51	53.58	85.9	88.0	59.20	114.91	10.30	1947-50	9.62
1951/52	67.90	80.8	81.2	77.37	117.55	13.16	1948-51	10.21
1952/53	14.78	80.0	74.8	18.09	122.63	2.95	1949-52	9.64
1953/54	56.40	61.2	57.2	64.24	131.25	9.79	1950-53	9.05
1954/55	39.94	61.5	50.2	45.61	130.25	7.00	1951-54	8.23
1955/56	61.58	81.0	62.2	70.04	129.55	10.81	1952-55	7.64
1956/57	74.39	65.5	48.2	90.46	136.51	13.25	1953-56	10.21
1957/58	18.55	71.3	64.2	24.17	141.05	3.43	1954-57	8.62
1958/59	35.78	61.9	58.7	43.15	147.20	5.86	1955-58	8.34
1959/60	57.16	59.2	59.1	62.50	152.84	8.18	1956-59	7.68

FIGURE XVIII

C. R. S. COMMERCIAL CROP — 1946-1959



A REVIEW OF COFFEE SEED ISSUES FROM THE COFFEE RESEARCH STATION IN RECENT YEARS

By J. B. D. ROBINSON, Senior Research Officer

One of the most important activities of this Station is to supply seed of proven selections to growers in Tanganyika at a nominal cost per pound. The seed is collected from special seed bearing mother trees (clonal trees) which have been established after many years of yield recording and quality assessment i.e. bean size and liquor quality. This selection work is still going on and as new selections are confirmed as being superior to the existing types being issued to growers, they are substituted in the fulfilment of the seed orders received each year.

Broadly speaking the seed issued from this Station is classified as Bourbon e.g. N series or Kents e.g. KP series, type coffee. The Bourbon types produce the better quality; the Kent types often yield more heavily. One other major difference is that Bourbon types are susceptible to the commonly occurring leaf-rust races I and II whereas the Kent types are immune to leaf-rust race II but are susceptible to race I. This does not invariably mean that Kent types suffer less leaf infection and leaf fall following leaf-rust attack but this is often observed to be the case. All of the Kent selections from Lyamungu are copper tipped; not all the Bourbon selections are green tipped and the current selections issued from Lyamungu are in fact all copper tipped.

The histogram in figure XIX shows the total seed issued of all varieties annually to growers in Tanganyika and the proportion which has been issued to plantation and African growers. In the fourteen year period from 1946 to 1959 a total of 50,158.75 lbs. of seed has been issued in Tanganyika. Theoretically this is sufficient to plant about 120,000 acres of coffee and even assuming a 50% loss at some stage between planting the seed in the nursery and planting out the seedling in the field i.e. germination, nursery transplant losses, there should have been an increase over the period of the order of 60,000 acres of coffee. Infilling will account for a high proportion of these seedlings in fact without showing any increase in acreage. The actual proportions distributed during this period were 22,132.0 lbs. sold to African growers, 27,269.5 lbs. sold to plantations and 757,25 lbs. sold to people outside Tanganyika.

The proportions of the total seed distributed from 1948 to 1959 represented by each of the main selections is shown in Table XVIII. The N selections represent 51.237% and the KP selections 29.586% of the total seed issued.

The changes in selections issued over this period are clearly seen in Table XIX. For example KP 265 was first issued in 1954, N 205 in 1951 whereas virtually no I selections have been issued since 1953 and little or no No. since 1954.

The greatest proportion of the seed has been distributed in the Northern Province with the Southern Highlands Province ranking a low second.

COFFEE SEED ISSUED ANNUALLY TO TANGANYIKA GROWERS

FIGURE XIX

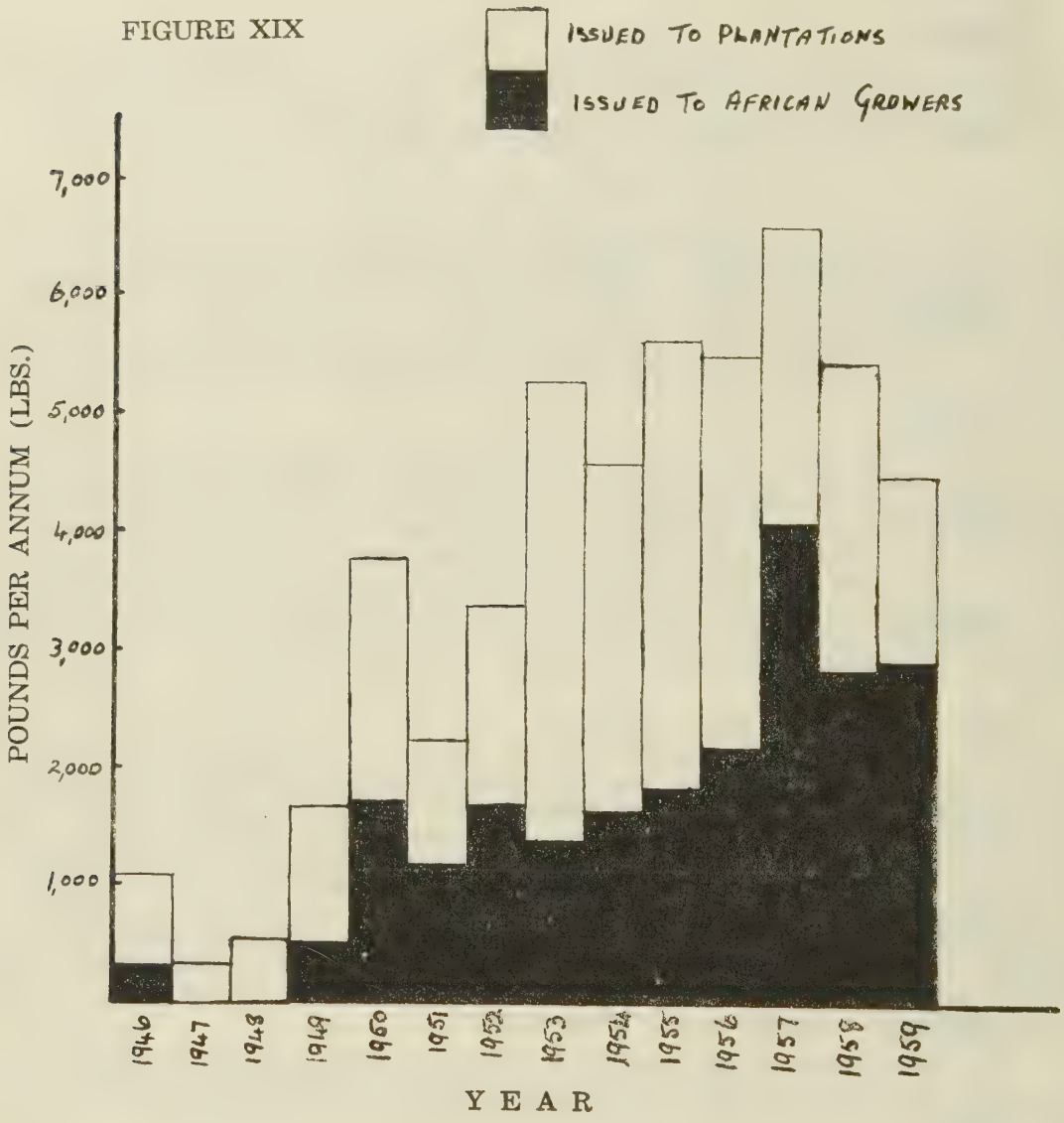


TABLE XVIII

Relative quantities of the different coffee selections distributed from 1948 to 1959

Selection	YEAR 1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	Total	% Ages *
N. 39 -	82	379¼	617½	378	405¼	783¾	1059	1252½	1250½	1524½	659	1166	9556¾	19.602
N. 197 -	51	163½	438¼	249	456	726½	512	1712½	1440¼	856¾	1228¼	709	8543	17.523
N. 205 -	—	—	—	20	78	81½	8	165¾	—	159¼	42	146¼	701	1.438
N. 218 -	6	22½	23½	1	66	35¾	72	144	93	234	9	230½	937¼	1.922
N. 5 - -	26	78¾	212	197	266½	358½	499½	13	319¼	473¾	238¼	431¾	3114¼	6.388
N. 0 - -	20½	171¾	504	307¾	433¾	540¼	145	—	5	½	—	—	2128¼	4.365
KP. 423	10½	54½	171	150¼	129¾	409	124½	256½	144¼	231¾	135¼	117½	1934¼	3.967
KP. 154	3½	4	100	101	93¼	324	131	298½	33	176½	194	134½	1593¼	3.268
KP. 162	—	5	½	140	84½	521	411	325¼	1345	229½	738	464	4263¾	8.745
KP. 532	14½	14¾	168½	92½	192	139	68	188	73¾	163	53	103	1270	2.605
KP. 265	—	—	—	—	—	—	7¼	—	—	239¼	214½	95	556	1.140
KP. 0 -	180½	269¼	387½	229¼	314½	666¼	316¼	483¼	328	654½	730	248	4807¼	9.860
H. 66 -	16½	48	86¾	127¼	227½	224½	715	381½	309¾	594¼	182	159	3072	6.301
I - - - -	—	201¼	57	5¾	¼	—	12½	—	¼	—	—	0	277	.568
F - - - -	—	—	60	38	104¾	109½	2	—	—	—	¼	1	315½	.647
KI - -)	31	142¼	293¼	5½	62¾	17	2½	—	2	177½	139½	100½	973¾	1.997
KIL -)	—	—	—	33½	64	139	280	168½	74	502	432	302	1995	4.092
X - - - -	—	—	—	—	124	58	79½	138	88¼	288¾	437	16	1230	2.523
P - - - -	43	27¾	110¾	7	15	3¾	—	43	—	—	6¼	¼	256¾	.527
L - - - -	26½	76	343	87¼	163¼	113¼	87	30	5	—	—	—	931¼	1.910
Mix - -	17½	16½	123	31¾	49½	55¾	3¾	½	—	—	—	—	298¼	.612
Totals	529	1675	3696½	3201¾	3329½	5306¾	4535¾	5600¾	5511¼	6505¾	5438¼	4424¼	48754½	100%

NOTES : * Percentages of grand total.

TABLE XIX

The distribution of coffee seed to the various Provinces in Tanganyika, 1946—1959

YEAR	PROVINCES									
	N.P.	S.H.P.	T.P.	W.P.	S.P.	E.P.	L.P.	C.P.	O	TOTAL
1946	457	624	9	—	—	—	5	—	—	1095
1947	163	132	10	—	—	—	—	—	—	305
1948	475	50	3	—	—	—	—	—	1	529
1949	1308	331	20	—	—	—	—	½	16	1675½
1950	3042½	524½	56½	1	10	10	—	—	52	3696½
1951	1475	392	30	½	—	110	¼	15	179	2201¾
1952	2317½	560	143	101	—	178	—	½	30	3330
1953	4267½	432½	151	124	63	142½	—	—	126¼	5306¾
1954	2995	802	245	144¼	15	120	11	—	206½	4538¾
1955	4207¾	751	360	129	1	82	31	10	29	5600¾
1956	3605	863	297	281	231	111	53	—	70¼	5511¼
1957	3757¼	1609¼	536	319	—	110½	126	17	30¾	6505¾
1958	3052	269	730	596	365	62	282	80	2¼	5438¼
1959	2283	701	380	600½	100	76	250	33	1	4424½
TOTAL	33,405½	8041¼	2970	2296¼	785	1002	758¼	156	744	50,158¾
Percentage of Total	66.500	16.132	5.921	4.578	1.565	1.998	1.512	0.311	1.483	100%

NOTES :

N.P. = Northern Province.
SHP = Southern Highlands Province
T.P. = Tanga Province
W.P. = Western Province
S.P. = Southern Province
E.P. = Eastern Province
L.P. = Lake Province
C.P. = Central Province
O = Outside Tanganyika

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